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AUTHOR INDEX

ARTICLES AND PROVINCIAL NOTES

ISSUES 1-12 1948-51

● The following index covers the articles and provincial notes contained in Vols. I-III. ● Pagination is continuous throughout each volume of four issues. ● It has been thought unnecessary to include abstracts in this index, but a list of abstractors who have contributed to the issues is given on p. iv.

VOL. 1 (ISSUES 1-4)

VOL. 2 (ISSUES 5-8)

VOL. 3 (ISSUES 9-12)

ABSTRACTORS

AGRICULTURE

T. Dalling, M.A., M.R.C.V.S.	Animal Health
R. G. Baskett, M.Sc.	Animal Nutrition
S. M. Boden, B.Sc., A.R.I.C.	ditto
W. Longrigg, B.Sc., N.D.A., N.D.D.	Animal Breeding
W. Morley Davies, M.A., B.Sc., F.R.I.C.	Soils
T. W. Williams, B.Sc.	Herbage
D. H. Robinson, B.Sc., Ph.D., N.D.A.	Crop Husbandry
C. Culpin, M.A.	Machinery

HORTICULTURE

H. B. S. Montgomery, B.A., Ph.D., D.I.C.	Fruit
E. Skillman, B.Sc., N.D.H.	Glasshouse Crops
R. H. Stoughton, D.Sc., A.R.C.S. ...	Flowers and Soilless Culture
William Plant, B.Sc.(Hort.), Ph.D., N.D.H.	Nutrition of Horticultural Crops
E. J. Winter, M.Sc.	Vegetable Crops
J. Philp, Ph.D.	ditto

GENETICS

J. L. Fyfe, M.Sc.	Crops and Plant Breeding

DAIRYING

A. T. R. Mattick, B.Sc., Ph.D.	Dairy Bacteriology
A. S. Foot, M.Sc.	Dairy Husbandry

POULTRY

R. Coles, M.Sc.(Econ.), B.A., Ph.D., M.Sc. ...	Poultry Husbandry

PLANT PATHOLOGY

L. N. Staniland, A.R.C.S.	Entomology
H. E. Croxall, B.Sc., Ph.D.	Mycology
Kenneth M. Smith, Ph.D., D.Sc., F.R.S.	Virology
H. Martin, D.Sc., A.R.C.S., F.R.I.C. ...	Insecticides and Fungicides

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CONTENTS

LONDON: HER MAJESTY'S STATIONERY OFFICE: 1952

ABSTRACTORS

AGRICULTURE

S. M. Boden, B.Sc., A.R.I.C.	*Animal Nutrition*
W. Morley Davies, M.A., B.Sc., F.R.I.C.	*Soils*
T. E. Williams, B.Sc.	*Herbage*
D. H. Robinson, B.Sc., Ph.D., N.D.A.	*Crop Husbandry**
C. Culpin, M.A.	*Machinery*

HORTICULTURE

H. B. S. Montgomery, B.A., Ph.D., D.I.C.	*Fruit*
E. Skillman, B.Sc., N.D.H.	*Glasshouse Crops*
R. H. Stoughton, D.Sc., A.R.C.S.	*Flowers and Soilless Culture*
William Plant, B.Sc.(Hort.), Ph.D., N.D.H	*Nutrition of Horticultural Crops**
E. J. Winter, M.Sc.	*Vegetable Crops*

GENETICS

J. L. Fyfe, M.Sc.	*Crops and Plant Breeding*

DAIRYING

A. T. R. Mattick, B.Sc., Ph.D.	*Dairy Bacteriology**
A. S. Foot, M.Sc.	*Dairy Husbandry*

POULTRY

R. Coles, M.Sc.(Econ.), B.A., Ph.D., M.Sc.	*Poultry Husbandry*

PLANT PATHOLOGY

L. N. Staniland, A.R.C.S.	*Entomology**
H. E. Croxall, B.Sc., Ph.D.	*Mycology*
Kenneth M. Smith, Ph.D., D.Sc., F.R.S.	*Virology**

*Not represented in this issue.

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ARTICLES

PROTEIN QUALITY AND THE ANIMAL PROTEIN FACTOR

J. E. Ford

National Institute for Research in Dairying, University of Reading

Until the beginning of the present century, proteins were regarded simply as a source of the essential dietary nitrogen : they were " proteins " and nothing more. With a recognition of the role of amino-acids in nutrition, knowledge of the nutritive values of different proteins increased rapidly.

It has long been customary to speak of first-class proteins and second-class proteins, those of animal origin being placed usually in the first category. They were known to have a special feeding value, which was at first linked with the nutritional quality of the protein itself. We now know that this quality corresponds in the main to the relative proportions and amounts of the different amino-acids they contain. This is especially so with those amino-acids that are not synthesized by the animal organism—the so-called " essential " amino-acids.

These considerations of protein quality apply only to single-stomached animals. For ruminants, protein quality is of little or no importance, since, in these animals, ingested proteins are largely broken down in the rumen and are subsequently re-synthesized into bacterial bodies which provide the protein requirements of the animal. Blaxter and Wood [1] have shown, however, that before its rumen develops, the young calf behaves like a non-ruminant and depends on its diet for essential amino-acids, as do single-stomached animals.

Proteins of animal origin generally contain a more satisfactory mixture of amino-acids than vegetable proteins, many of which are poor in lysine, methionine or tryptophan. But in practice, protein foods are not used singly but in admixture, and the feeding value of a defective protein is largely determined by the ability of the other proteins present in the diet to compensate for its amino-acid deficiencies. Many examples of such supplementary relationships are known ; for instance, those between the proteins of meat or milk and those of cereals or potatoes. It is possible, in fact, by using appropriate mixtures of vegetable proteins alone, to compound diets equivalent in amino-acid composition to diets rich in " first-class " animal protein.

Nevertheless, many workers have found recently that single-stomached animals, e.g., pigs, poultry, rats and mice, grow poorly

when fed on rations based largely on vegetable or highly purified animal proteins, though the amino-acid composition appears adequate. One of the earliest to provide an explanation was Nestler [2] who, in 1936, described a factor present in animal proteins which increased the hatchability of hen eggs. In 1946, Cary *et al.* [3] added further evidence by showing that young rats, which grew normally if on a diet based largely on crude casein, failed to do so when the casein was purified. Normal growth was obtained, however, when the purified casein diet was supplemented with various animal foods or a liver extract. Thus a factor accompanying animal protein, rather than the protein itself, appeared to be involved. Hammond [4], with Rubin and Bird [5], described a " Cow Manure Factor " that stimulated the growth of chicks fed on a vegetable protein diet, and Zucker and Zucker [6], [7] a rat growth factor in animal proteins which they called " Zoopherin."

It is now well established, by these and other workers, that the special value of animal proteins in nutrition is not theirs entirely by virtue of amino-acid composition, but is largely contributed by their content of an essential growth factor or group of factors, the so-called " Animal Protein Factor " (A.P.F.) absent from vegetable proteins. An important component of the A.P.F. is the recently isolated anti-pernicious anaemia factor, now known as vitamin B_{12}. But it is as a growth factor and not as a haemopoietic factor that the vitamin is important in animal nutrition, and attempts to induce in animals a condition akin to pernicious anaemia in man have met with no success.

The pure vitamin can largely reproduce the activities of the factors mentioned above and it was at first accepted as being in itself the " Animal Protein Factor." Later work points, however, to the existence of other and as yet unidentified components of the A.P.F., but it is clear that vitamin B_{12} is essential for rapid early growth of certain animals, including pigs and poultry, and is of practical importance in the feeding of these animals.

Besides the A.P.F., other and well-defined vitamins are important in animal nutrition, and, of these, riboflavin shows a marked association with animal products. We must, therefore, in evaluating a protein, consider its component values—as a source of amino-acids, as a carrier of A.P.F. and other vitamins and possibly also of mineral elements.

Occurrence of Vitamin B_{12} and Related Factors

Vitamin B_{12} is a red, cobalt-containing compound and is one of a group of substances which are closely related chemically, and are of wide occurrence, though in minute amount, in animal products and in gut contents and other materials subjected to bacterial fermentation. Though the A.P.F. as represented by vitamin B_{12} is by no means exclusively associated with animal protein, it is not present in significant amounts in plant proteins. It is, of course, not of a proteinous nature, and is now largely derived from micro-organisms, being obtained as an important by-product of the antibiotics industry.

It may be that the complete synthesis of vitamin B_{12} is carried out only by micro-organisms, but higher animals can perhaps complete

the synthesis from intermediary compounds. The vitamin is of value not only to higher animals but is an essential growth factor for a number of micro-organisms ; in fact, the vitamin is now largely measured by microbiological assay. Some of the related compounds are also active for animals but others are inactive, though fully active for certain micro-organisms. Hence, whenever these compounds are likely to be present, the validity of microbiological tests must be checked with higher animals—for example, by chick assay. Coates, Ford *et al.* [8] found that two such compounds, isolated from calf faeces, were inactive for the chick when fed with the diet, but that one of them greatly increased the response of the chick to added vitamin B_{12}. The gut contents and faeces of the chick, calf, pig and horse are rich sources of these related compounds. In fact, only about 10 per cent of the vitamin B_{12} activity of calf faeces, measured by microbiological assay, is contributed by that vitamin itself, although the vitamin B_{12} content increases on bacterial fermentation after voiding, possibly by reason of a conversion to the vitamin of related factors.

There can be no doubt that adult ruminant animals make use of vitamin B_{12} synthesized by gut organisms. On the other hand, it is evident that such synthesis does not adequately provide the vitamin B_{12} needs of growing pigs and poultry. In our experience with these animals, liver storage of the vitamin reflects the dietary intake, despite the abundant amounts of the vitamin synthesized by the gut flora, even of animals fed on rations deficient in vitamin B_{12}. A likely explanation is that vitamin B_{12}, synthesized by caecal micro-organisms—and the caecum is probably the main site of synthesis in non-ruminants—remains confined within bacterial cells and is therefore unavailable to the host animal.

The A.P.F. in the Nutrition of Poultry and Pigs

Several workers have shown that vitamin B_{12} can promote the growth of chicks fed on all-vegetable rations, and can also restore the hatchability of eggs from hens fed on such diets.

Evidence is now accumulating that, in addition to vitamin B_{12}, other, as yet unidentified, components of the A.P.F. are needed for egg production and hatchability, and for chick growth. Coates *et al.* [9] found that hens kept for a long period on a vegetable diet became depleted of another factor or factors present in condensed fish solubles. They found, also, that the vitamin B_{12} activity for chicks of a number of crude materials, including fish solubles, was much higher than indicated by microbiological assay for vitamin B_{12}. Other workers have published essentially similar findings.

With pigs, there is some confusion of evidence about the ability of vitamin B_{12} to improve growth on vegetable diets ; but, in the main, it is clear that growing pigs, fed on diets low in vitamin B_{12}, respond to the vitamin either in the pure state or, and here there is wider agreement, in the form of an A.P.F. supplement.

The Growth-Promoting Effect of Antibiotics

A recent remarkable observation was that antibiotics, fed with the diet, have a marked effect on the growth of animals. It was found that certain A.P.F. concentrates, made from cultures of *Streptomyces aureofaciens*, and used as a commercial source of vitamin B_{12}, caused in chicks a growth response greater than could be obtained with vitamin B_{12} alone. This effect was later shown to be due to the antibiotic aureomycin present in the concentrates (Stokstad and Jukes [10]). This effect is not specific to aureomycin, but is common to a number of anti-bacterial substances (Coates *et al.* [11]) and can almost certainly be attributed to their effect on the gut flora which can be supposed to be altered in a manner that benefits the host, possibly by the suppression of organisms which are competing with him for growth factors or other food constituents ; or conversely, by the encouragement of organisms which contribute to his welfare, perhaps by the synthesis of unknown growth factors. The suppression of the competition for vitamin B_{12} by gut organisms is indicated by a marked mutual sparing relationship between the vitamin and antibiotics. Such a sparing effect of antibiotics is, of course, more likely to be evident with deficient diets, and in fact it is unlikely that a single mode of action will be found to explain all the effects of antibiotics so far reported. Under some circumstances, their effect, at least with chicks, is undoubtedly to suppress an otherwise inapparent " infection " resulting in depression of growth. Thus Coates, Dickinson *et al.* [12] found that chicks reared in a laboratory where birds had not been kept before grew equally well both with and without penicillin in the diet, whereas chicks from the same batch reared in another laboratory where birds had been kept for some years grew better with penicillin. They showed that the " infection " is transmissible and can be counteracted by penicillin. These findings may perhaps be connected with " beginner's luck " in poultry-keeping, and the experience that performance tends to decline in premises where birds have been kept intensively for a long time.

Several workers have found that the value to pigs and poultry of all-vegetable diets can be increased, by the addition of an A.P.F. supplement containing aureomycin, to full equality with optimal " natural " diets. This is of great interest, but does not warrant the conclusion that vegetable diets can thus be ennobled in all respects, since clearly the antibiotic does not in any real sense make good an A.P.F. or other vitamin deficiency of the vegetable diets, let alone any serious shortcomings in amino-acids or minerals. It is obvious that this growth-promoting effect of antibiotics, besides being of scientific interest, is of potential practical and economic importance. But, before general application in livestock feeding is justified, it must first be shown that it has no serious disadvantages in the long run.

The A.P.F. and the Feeding Value of Proteins

There is growing evidence that vitamin B_{12} plays an important part in protein utilization and that it is particularly concerned in the meta-

bolism of the essential amino-acid, methionine. It appears to be needed for the transformation of homocystine to methionine by the chick and the rat, and it decreases the chick's need for choline. There is some evidence that it can improve the biological value of diets low in methionine. With rats, the addition of either vitamin B_{12} or methionine improved utilization of a purified casein to about the same extent (Henry and Kon [13]). With chicks also, there was found a mutual sparing action between vitamin B_{12} and methionine (Jukes, Stokstad and Broquist [14]). But, in the main, little work has yet been done on the effect of vitamin B_{12} on the biological value of proteins. It is, in fact, open to question whether or not we can justly compute biological values for vegetable proteins without first making provision in the diet for all the other growth requirements of the test animal. Certainly, from the practical feeding standpoint, interest centres on the possibility of economically substituting vegetable for animal protein in pig and poultry rations, supplemented with the A.P.F.

There is little evidence, on the whole, that gross amino-acid defects can be ameliorated by vitamin B_{12} or A.P.F., and it is important that practical diets so supplemented should contain a proper balance of amino-acids. Such a balance can be obtained by using mixtures of vegetable proteins only. In fact, soya protein alone is similar in amino-acid composition to a number of animal proteins; and further, it is able, by virtue of its high lysine content, to supplement cereal proteins. The abundance of soya protein and relative scarcity of animal protein in the United States has established there the widespread use of A.P.F. supplements in pig and poultry rations based on soya protein. In other areas of the world too, where animal protein foods are not available, it seems likely that the use of concentrates rich in A.P.F. will enable better use to be made of vegetable feedingstuffs. But in this country there is no such incentive to feed wholly vegetable rations and it is very doubtful whether such a change would prove economically worth while. A further consideration is that the animal proteins in common use here, in particular fishmeal, are rich sources of riboflavin and other B-complex vitamins, and also of minerals—all of great importance for pigs and poultry; their use certainly greatly simplifies the problems of compounding rations for these animals.

Woodman and Evans [15] found that, with young pigs, economical use of groundnut meal was achieved by feeding it in conjunction with fishmeal. A diet containing 6 per cent groundnut meal and 2 per cent white fishmeal gave as good growth as another containing 15 per cent groundnut meal. But, on the other hand, a wholly vegetable diet containing 20 per cent groundnut meal gave the same rate of growth and efficiency of food conversion as were obtained with an optimal diet containing 7 per cent fishmeal. Evidently, the inferiority of the groundnut protein could be overcome by feeding it at a higher level, even in the presumable absence of dietary A.P.F. In general, however, attempts to eliminate animal proteins from pig and poultry rations have resulted in poor growth, made worse by raising the level of certain sources of vegetable protein, such as soya bean.

It may prove that animals reared under farm conditions and having access to litter are less susceptible to dietary deficiency of A.P.F. than intensively reared animals, or that adult animals can in part compensate for the deficiency by the activity of intestinal micro-organisms. On the whole, however, we can conclude that, under intensive rearing conditions, simple-stomached animals are likely to grow poorly when fed on wholly vegetable diets. In making provision for their nutrition, we must remember that the great importance of animal proteins lies largely in their contributing other factors besides amino-acids.

The wide use of A.P.F. supplements, and in particular, those containing antibiotics, holds out great promise of economy in the general utilization of foodstuffs, and in particular of expensive animal proteins. It remains for the future to show to what extent their use will prove of value in this country.

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WOOL

A. B. Wildman

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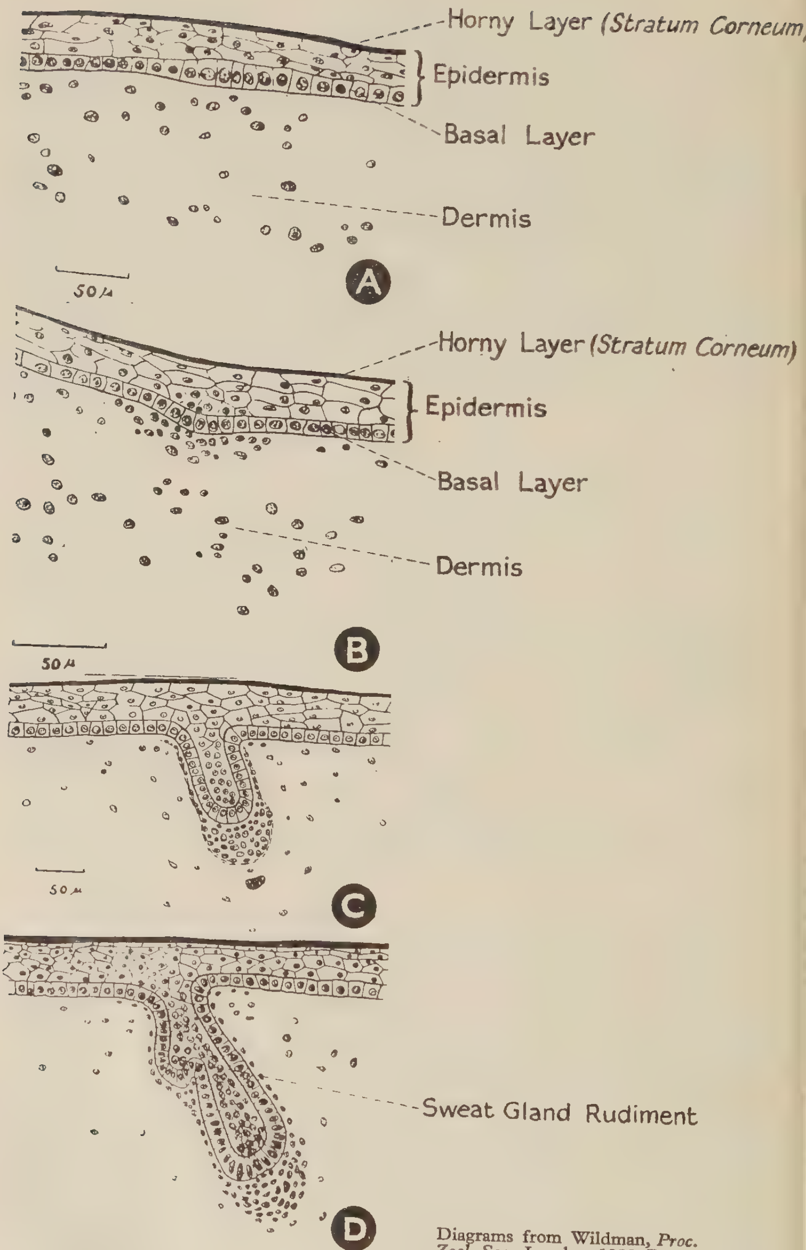
The title of this article has been made brief advisedly, because it is not intended to confine the text to one particular aspect of wool research; although some results of wool biological research will be indicated, the production of wool from British sheep will also be discussed in perspective with the requirements of the user and the problems of the farmer. Wool is, and has been, regarded as a by-product of the sheep, but there is no reason why it should not often be made a much better by-product than it is at present. If we are to advise a farmer on the best way to set about improving his wool clip under his own special conditions, we must have some understanding of the nature of wool and how its growth and form are affected under farm conditions. In the first instance, then, let us consider the general structure of a single wool fibre, and how it starts its growth in the skin and develops until it has pushed above the surface.

A typical wool fibre of small to medium thickness, when sectioned across, is seen to be made up of two main parts: an outer cuticle, composed of a thin layer of overlapping scale-like units, and within this the main body or cortex of the fibre, which consists of cornified cells, called the cortical cells, which are pressed against each other laterally, each being normally about twenty times as long as it is wide at its widest part. Within each cortical cell is a number of very small, longitudinally arranged fibrils analagous to small muscle fibrils. In each cortical cell reside those properties, e.g., elasticity, power to absorb water, which confer on the wool fibre its many well-known desirable attributes. The whole of the fibre consists of a type of keratin, i.e., a "horny" protein of long chain molecules, linked laterally. Coarser fibres may contain a central "medulla," but this is discussed later in the article.

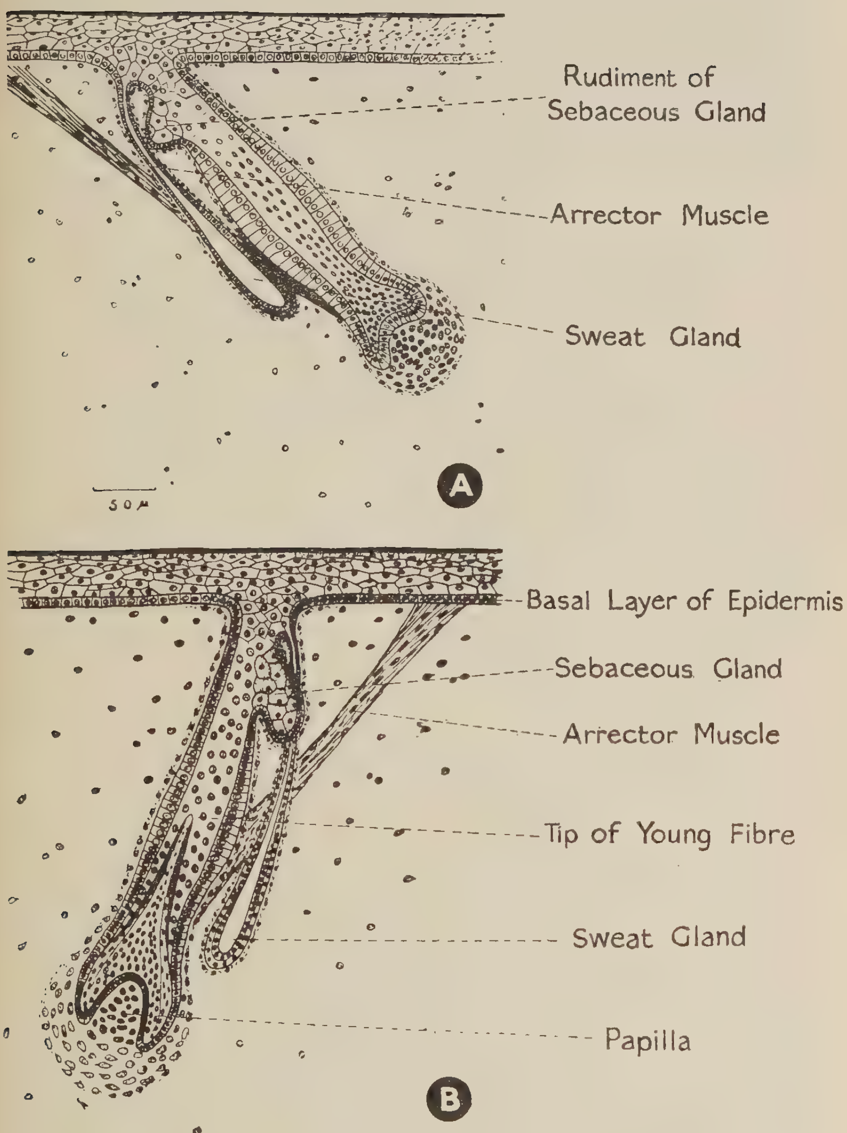
The Development of the Wool Follicle and Fibre

To see the structure of the young, developing follicle and fibre we may cut a small piece of skin from a few-months-old sheep foetus and section it at right angles to the plane of the skin surface, and along the slope of the follicle, so as to a produce a series of sections about 8μ thick, which can then be stained. Microscopical examination of the section will show a number of follicles in various stages of development in longitudinal section. The skin itself consists of the epidermis above a "lower skin" or dermis (Figs. 1 and 2). Lining the under part of the epidermis is a single layer of cells, the basal layer, and the cells of this layer are very active, being meristematic, i.e., continually dividing to form fresh epidermal cells which, in turn, are pushed towards the skin surface. As these cells are developed, they become cornified and finally form a thin keratinized covering on the surface of the epidermis.



Diagrams from Wildman, *Proc. Zool. Soc.*, London, 1932, Pt. II.

Fig. 1. A—D represent vertical sections of skin from a sheep foetus; showing early stages in follicle development.



Diagrams from Wildman, *Proc. Zool. Soc.*, London, 1932, Pt. II.

Fig. 2 Successive stages in follicle and fibre development.

When a fibre is going to develop, a series of changes occurs in a part of the basal layer resulting in a small, downwardly-growing plug of epidermal cells. The plug, lined by cells of the basal layer, is the young follicle, and, later on, the young fibre will be differentiated from its base (Fig. 1, and Plate I of art inset). At this early stage, there is still no sign of a fibre, but some cells of the dermis have differentiated to form a connective-tissue sheath round the follicle, and small blood capillaries which supply nutriment to the newly-organized tissue.

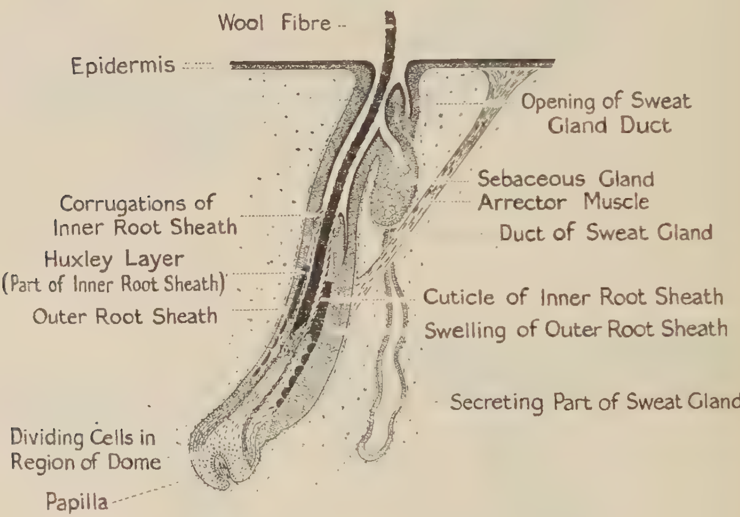


Fig 3. Diagram (by Auber) of vertical section of mature wool follicle.

About this time, small outgrowths from the neck of the follicle are making their appearance, and these (Fig. 1, and Plate I) are the rudiments of the bilobed wax or sebaceous gland and the sweat or sudoriferous gland : as we shall see, not all follicles possess sweat glands. The cells at and round the base of the follicle are now dividing rapidly to form new tissues. Towards the centre of the follicle plug, and a little above its base, the cells become more elongated : these are the cells which are going to form the fibre with its surrounding inner root sheath (Fig. 2, A, and Plate I, C). A small two-banded muscle is formed and, later, this becomes inserted on to the follicle and attached to the epidermis above ; this is the arrector muscle (Figs. 2 and 3 ; Plates II and III, A), and when it contracts in certain mammals and sometimes in humans, it pulls at the follicle and causes the fibre to " stand on end."

The ever-increasing number of polyhedral-shaped cells, over the " dome " of the follicle (Fig. 2, B, and Plates II and III, A) become elongated, those towards the side of the dome forming layers of the inner root sheath which closely invests and grows up with the young fibre : the latter is formed from the more centrally-placed cells which stream upwards from the apical region of the follicular dome. As the cells of the forming fibre are pushed further up and away from the dome or growing point, their central nuclei become reduced in size and there is laid down in the cytoplasm a substance which is a precursor of keratin, i.e., the " horn " of the mature fibre. This cornification or keratinization of follicular structures proceeds faster, and starts lower down, more particularly in the cells forming the outermost layer of the inner root sheath (Fig. 3, and Plates II and III, A), than it does in the more centrally-situated cells which form the fibre.

The presence of this comparatively rigid sheath round the still soft, plastic young fibre cells, and the direction of the growing point at the apex of the dome, are important factors in determining the shape of the fibre, so significant in its influence on staple form, when it emerges from the skin. The tip of the young fibre (Fig. 2, B, and Plate II, B) pushes its way, by pressure of dividing cells below, up through the plug of cells in the follicle, and near the top it finds its way made easier by the action of the sebaceous or wax gland. This gland is already active and has pushed wax cells into the neck of the young follicle ; these comparatively large wax cells have excavated a passage through the top part of the follicular plug (Plate II, C). The passage leads past the entrance of the sweat gland duct and " turns the corner," as it were, in the epidermis proper. The tip of the growing fibre follows the line of least resistance in the passage to the " cul-de-sac " in the epidermis. Pressure due to dividing cells near the base of the follicle is transmitted up the long axis of the fibre which then arches at the tip. This tip is thin and is, as yet, unable to burst through the tough outer layer of the epidermis ; the result, looking down on the skin surface, is a kind of pimple. Gradually, the pressure becomes too great for the horny layer (*stratum corneum*) to withstand and it ruptures, allowing the tip of the fibre to spring out above the skin surface. As they grow, both fibre and follicle tend to curve in two different planes and form a spiral : there are few if any animal fibres which are absolutely straight.

Groups of Follicles and Fibres and their Significance

The first follicles to be formed in the skin of a foetus are widely spaced, but at a comparatively early stage in many parts of the body the follicles are grouped in threes to form what we call a " trio group." This grouping is thought to be primitive, and follicles developed up to the trio stage are known as *primary follicles.* Other young follicles, the *secondary follicles*, now begin to develop on one side of each trio group and adjacent to each primary follicle until a follicle bundle is formed (Plate III, B). The primary follicles possess sweat glands but the secondary follicles usually do not. A typical follicle

bundle consists, therefore, of three primary follicles with a comparatively large but variable number of secondary follicles, and it is this bundle which is the fundamental unit of the growing fleece. The primary follicles produce the first developing fibres of the birthcoat, often hairy and strongly medullated fibres, including kemps (see below): the secondary follicles produce the later-growing and often finer fleece fibres.

Fibres from secondary follicles, particularly in breeds which do not grow very hairy fleeces, frequently constitute the bulk of the fleece. The ratio of secondary to primary follicles is important in influencing the character of the resultant fleece. A certain amount of evidence has been accumulated on which is based the suggestion that the kind and amount of nutrition in the early part of the lamb's life affects the number of secondary follicles which are formed, and thus the amount and character of the fleece. If this is shown to be true, then it is of considerable practical importance.

Fibre Types in the Fleece

There are, of course, a large number of fibres in the fleeces of sheep which differ slightly in structural detail, but we shall consider three main types which may occur in mature fleeces.

Kemp Fibres

The fibres are coarse, usually fairly short, chalky white in colour, and occur more frequently in the fleeces of hill and mountain sheep. They are not persistently-growing, but, unlike the majority of fleece fibres, they are shed annually and are replaced. A kemp fibre tapers very gradually to the tip, giving a whiplash appearance, and the root end appears as a minute knob, indicating that the fibre has been shed from its follicle. When viewed through the microscope, a kemp fibre is seen to have a very large central core or medulla with " struts " forming a meshwork enclosing inter-connecting spaces containing air or gases.* The medulla is so wide that the solid part of the fibre consists only of a relatively thin outer " cylinder " of keratin. The pattern sequence, formed by the cuticular scales on the outside of the fibre, is the same in all kemp fibres. When mixed with other fibres in a fabric, kemps, because of their structure, scatter the light, and have very little solid substance to take dye: they therefore appear whiter than the other fibres and are usually considered to be objectionable by the manufacturer.

Where kemp fibres occur in a fleece, the greatest amount is usually found about the root of the tail or on the britch.

Persistently-Growing Hairs

These are usually coarse and, particularly in very coarse types such as the deep hair of some Scotch Blackfaces, which is used in

*The exact nature of the intra-medullary atmosphere is not yet known.

mattress making, they often have a structure similar to the kemp fibre. They differ from kemps, however, in being persistently-growing, and not usually being shed ; often these fibres are not quite so coarse as kemps and although they possess a medulla, this may not occupy as much of the fibre as it does in the kemp. These medullated fibres are, of course, present in fleeces of many breeds of sheep, but are scarce or absent in the finest Down fleeces. The surface cuticular scale pattern is characteristic.

True Wool Fibres

By " true wool fibres " we mean relatively fine, usually curled or crimped, persistently-growing fibres. Nearly all British fleeces possess some true wool fibres ; in the finest Down breeds, they constitute the bulk of the fleece, whilst in a double-coated breed such as the Scotch Blackface, they form the undercoat only.

In a great many types of British sheep, particularly breeds such as the Welsh Mountain and others which do not usually grow an even, fine fleece, the variation between fleeces and between fibres in a fleece is very often extremely great : all kinds of fibres intermediate between the thickest medullated hairs and the finest non-medullated or solid fine-wool fibres coexist in the same fleece.

Variation in Fleeces and its Causes

This is a subject so large that it cannot be discussed fully within the limits of an article of this kind : a few facts and principles may, however, be stated, and stimulate the making of observations and further inquiries by the reader. Variation in wool is, of course, the result of environment (including nutrition) and genetics, and the interplay of these two factors. Let us consider variation in fibre thickness.

Variation between regions of a fleece, e.g., the sort of variation which exists between neck, shoulder, back, rump, side and britch regions, is, broadly speaking, genetic in character and can be reduced by careful breeding and selection. Variation between fibres in structure, thickness, rate of growth in length, density, etc., is also largely genetic in character (Plate IV). Variation in thickness along the lengths of fibres is largely a matter of environment working through nutrition ; fibres are thinnest during periods in the season of low feed. Rate of growth in length also is usually less during these periods. However, it must be borne in mind that the genetic make-up of a sheep will influence its *degree of response* to such environmental conditions ; although all animals in a flock grow thinner and shorter fibres during lean periods, some animals will have thicker and longer fibres than others under the same conditions.

During periods of optimum nourishment, e.g., full flush of grass, the sheep's wool growth is the maximum of which it is capable and the fibre diameter is directly proportional to its length ; but this is not so when wool growth is not optimum. Research has demonstrated this

fact, and a test of whether wool growth is optimum is to see if the fibre thickness is directly proportional to its length. A comparison of the wool performance of different animals can be accurately made, therefore, only if the judgment is made on samples of wool which have been grown during the optimum growth period. The usual twelve-months-grown samples include wool produced during this period, plus, of course, wool grown during poor growing conditions.

The Wool Grower and the Manufacturer

Improved wool does not necessarily mean finer wool. Each broad type of British wool is used in the manufacturing industries for a specific purpose : the wool trade needs these different types. Above all, the wool buyer and manufacturer need *even* clips : that is, the more uniform that the wool is in a flock, between fleeces, in different body regions of each fleece, and between fibres, the less time and money is expended in sorting. The important condition to aim at is that wool should be as *uniform as possible for its type.* Can this be achieved ? The farmer can go a long way towards improving the uniformity of his clip and its value by attempting to observe the following points :

1. Selection for fleece uniformity by body regions, the elimination of over-coarse hairy britches and so on, has been and is being done by some breeders. The statement that " Good wool cannot be grown as well as good mutton " is not true. Generally speaking, the sheep which has good conformation, thrives well from birth, and has a fairly dense and uniform fleece, will produce a good weight of good wool and will be profitable from a wool point of view.

2. If at all possible, a levelling-up of feed through the year will help to produce fibres which are more uniform along their lengths. Thus, winter supplements help considerably, although it is realized that this desideratum is not always possible.

3. Selection against coloured fibres is important since these cannot be dyed the same as white fibres, and are highly objectionable. Unfortunately, pigmented fibres in the fleece are often linked with colour of face, and dark-faced breeds have this fault more frequently than white or even brockit-faced breeds. However, even in dark-faced breeds, pigmented fibres can be reduced by selection. In some breeds (Swaledale and others), dark fibres just behind the head are regarded as an indication of hardiness. Whilst it may be true that, in the past, hardy strains with this coloration have occurred, it is possible for hardy white-fleeced strains to be developed. Many breeders of Welsh Mountain sheep regard the tan face as an indication of hardiness : again, unfortunately, the tan face is linked genetically with red kemp fibres in the fleece and these are highly objectionable to the wool man.

4. Care should be taken to skirt off dirty daggings and pieces from fleeces, and place them in separate lots. Fleeces should be carefully rolled on clean, dry floors and not contaminated by coloured

fibres from other fleeces, straw, binder twine, chaff, etc. Fleeces, which should be as free as possible from paint and tar marks, should not be stained by dips which will not wash out, and should be stored in a dry place.

Many more problems of the wool producer and manufacturer could be cited, some of which are reconcilable and others conflicting. Usually, however, a compromise can be made, and there is ample scope for the improvement of the British wool clip in both weight and quality.

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ABSTRACTS

ANIMAL NUTRITION

Colostrum and the Calf

The function of colostrum in the nutrition of the calf has recently been reinvestigated. It has been considered for a long time that immune bodies, produced in the body of the cow in response to exposure to certain disease organisms, are transferred to the colostrum and thence to the blood of the calf which thus gains immediate protection against these same organisms. Since the immune bodies are protein in nature, and since their activity is dependent on their being transferred intact, it follows that they must not be subjected to the action of protein-splitting enzymes in the calf's gut, and that the walls of the gut must be permeable to them. It has, therefore, been postulated that, in the first few days of post-natal life, the nature of the digestive organs and of the processes occurring therein is markedly different from that subsequently established. Previous evidence on this point is supported and confirmed by observations of changes in the cells of the lining of the calf's intestine which suggest that, during the first 24 or 48 hours of life, the intestine is able to allow the passage of unchanged protein[1].

A series of papers, in which the value of the colostrum has been closely investigated, has recently appeared from the National Institute for Research in Dairying, and the Royal Veterinary College. In the first experiment[2], calves were fed on a diet of skimmed milk, margarine, glucose and vitamins A and D. During the first two days, they received one of six treatments : (*a*) colostrum ; (*b*) crude fat from colostrum ; (*c*) clarified fat from colostrum ; (*d*) colostrum free from fat ; (*e*) colostrum reconstituted from its components ; (*f*) no colostrum.

Those on (*a*), (*d*), and (*e*) did well, those on (*b*) did moderately well, and those on (*c*) and (*f*) badly; only one in three of the (*f*) group survived. It appeared that the important colostral factor was in the non-fatty portion, and that the moderate result with (*b*) was due to a quantity of entrained non-fatty material. This experiment had been conducted with appreciable quantities of colostrum; calves in (*a*), for example, received about $1\frac{1}{2}$ gallons. Further work[3] showed that about $1\frac{1}{2}$ pints of the non-fatty fraction was quite adequate and some protection was afforded by even a few ounces. This protection was due to an immune lactoglobulin which could be detected[4] in the calf's blood after as little as 7 ounces of the fraction had been given.

The same group of workers has also studied the effect of the pre-partum milking which sometimes becomes necessary when cows are steamed up before calving[5]. Calves were fed on the same " synthetic " milk as before, after being treated in one of the three following ways: (*a*) given 5 pints of colostrum taken from 5 heifers; (*b*) given 5 pints of milk taken from the same 5 heifers 14 days after calving; (*c*) 5 pints of " milk " (post-partum secretion) obtained within 24 hours of calving from cows which had been milked out for 14 days before calving. The materials had all been kept in cold storage until required. There was a high mortality in groups (*b*) and (*c*), but no deaths occurred in (*a*). This showed the pre-eminence of true colostrum as a protective agent and emphasized the need for conserving colostrum should pre-partum milking ever be necessary.

All the deaths in this last experiment were due to infection with Bacterium coli, and further papers[6] [7] dealt with the immunological aspects of the work. While the evidence was not conclusive, it appeared likely that colostrum contains " K " antibodies active against the " K " antigens which are possessed by the strains of Bacterium coli responsible for white scour in calves. The authors stress, however, that colostrum may have other factors of importance for the protection of calves.

Milk and Milk Substitutes in Calf Nutrition

It would be expected that cow's milk would be a very efficient food for the calf, and some recent work[8] certainly bears this out; 95 per cent of the gross energy of the milk was metabolized, and the net availability of this metabolized portion was 85 per cent. In the face of this, it is obvious that milk substitutes have been set a high standard to attain, but the search for these goes on because the desire to liberate milk for the market is always strong.

Work has been reported from New Zealand[9] on two sets of Jersey calves, the first receiving 60 gallons whole milk before being weaned at 8 weeks, and the second 30 gallons whole milk and 140 gallons skim milk before weaning at 18 weeks; both sets were grazed together from 4 weeks. At 18 weeks, the average weight of the second group was 28 lb. more than that of the first, but at 8 months the difference was only 9 lb. It was concluded that most of the calves could be weaned at 8 weeks provided good-quality grazing was also available.

Experiments using dried skim milk and dried whey in replacement of whole milk have been reported. A mixture containing 50 per cent dried skim milk and 30 per cent dried whey allowed normal growth, but the growth rate was retarded when mixtures with 60 per cent whey or 20 per cent dried beet pulp were employed[10]. The retarding effect of beet pulp has been found by others[11] who were unable to offset it by vitamins or protein supplements.

Early weaning has been attempted on systems of rearing which have included no whole milk[12]. Calves were given colostrum for three days and thereafter received skim milk plus fat-soluble vitamins; weaning was effected at times varying from 1 to 3 months. At 6 months, most calves were below the normal, but by 12 months normal weights had been reached.

The outstanding value of lactose as a form of carbohydrate in calf nutrition has been shown[13], [14]. Calves were fed on synthetic milks containing casein, lard, salts and different types of carbohydrate. When lactose was included, the gain in weight was twice as great as when it was absent, and the general health was also much improved.

The function of rumination becomes established in the calf when ruminal organisms are conveyed by natural infection from older animals, and solid food is simultaneously being consumed. If the organisms are implanted artificially, then rumination can begin at an earlier age; thus less milk need be fed and the calf will obtain vitamins from both the solid food and microfloral synthesis. A series of papers on cud inoculation has appeared recently, two of which [15], [16] may be cited as typical.

From a week old, calves are encouraged to take solid food (best hay, dried grass, young fresh grass, etc.) by restricting the amount of milk given, and cud material from cows is introduced into their mouths. Fibre (cellulose) is found to be digested better in inoculated than in uninoculated calves, the rumen develops more rapidly, and there does not seem to be any adverse effect due to the shortening of the milk-feeding period.

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S.M.B.

SOILS

The Mechanical Application of Fertilizers in Field Experiments. G. W. COOKE. *Emp. J. exp. Agric.*, 1951, **19**, 160-74.

In field experimentation, fertilizers have to be drilled or broadcast with greater precision than in ordinary farm practice. In this country, however, machines specially constructed for this work are not readily available, and local workers may often have to make use of commercial types of fertilizer distributors for dressing their experimental plots.

Guidance is given in this paper on the mechanisms and limitations for accurate field work of both special and commercial fertilizer distributors.

In the " top-delivery " machines designed for accurate field work, the fertilizer is forced upwards to the rim of the hopper by a gradually rising false bottom, and is scraped off as it reaches the top of the hopper. This type of machine needs to be run over non-experimental ground first, rejecting the initial delivery, until the delivery rate becomes even, with the consolidation of the fertilizer.

" End-delivery " machines deliver the fertilizer spread evenly on the upper section of an endless belt, and discharge a given load exactly

within a certain distance. This type of machine is indispensable when a number of fertilizers or mixtures of different bulk densities are to be distributed, perhaps at several rates.

Mechanisms in commercial distributors deliver the fertilizer by volume, so that changes in bulk density of the fertilizer are reflected in the weight of fertilizer delivered. The mechanism should have a positive action, i.e., deliver a definite volume of fertilizer for a given movement of the parts of the machine which displace fertilizer from the hopper.

In some commercial distributors, the fertilizer falls by gravity on to the surface of a horizontal, revolving disc at the base of the hopper; part of the disc emerges outside the hopper, and a scraper removes the fertilizer as fast as it is raised. The disc is often replaced by a toothed " star-wheel," similarly placed, the rate of delivery of the fertilizer determined mainly by the depth and spacing of the teeth. The thin type of " star-wheel," which is used in some machines, delivers fertilizer both from the teeth and at the surface of the wheel. Other commercial machines involve reciprocating perforated plates through which the fertilizer falls by gravity, as the plates move sideways.

In vertical wheel mechanisms, similar to the foregoing except that the axis of the wheel is horizontal instead of vertical, fertilizer falls by gravity between the spaces in a toothed wheel (as water falls into an overshot type water-wheel). Machines of this type may also have an adjustable gate which allows the flow of more fertilizer than is contained between the teeth. The gate is necessary with badly-conditioned fertilizers, but it may allow granular types of fertilizer to flow at uncontrolled rates. A shaft, with paddles turning over the wheel, is sometimes added to assist gravity flow and to prevent " bridging " of the fertilizer.

Calibration and field tests with machines incorporating these mechanisms are described. It was found that powdered National Compound No. 1, in contact with damp air during autumn storage in a shed, increased its moisture content from 3.2 to 10.6 per cent; with granular No. 1, the rise was from 2.3 to only 2.9 per cent.

These differences in the final moisture contents after storage were reflected in the corresponding differences in the rates of delivery from both disc-and-scraper and star-wheel mechanisms, as compared with the rate for dry fertilizer, the variation being large for the powder form and small for the granular form. The delivery of moist granular fertilizer by top-delivery machines was, however, more irregular than with drier material. In those machines, the delivery rate of damp, powdered fertilizer was most unsatisfactory. Vertical-wheel machines proved to be most unreliable, especially with powdered fertilizer, so that they are not suitable for use on field experiment plots. A number of useful references to different types of fertilizer distributors and to detailed studies of their performance are quoted in the text.

A. J. L. L.

W. M. D.

Soil Phosphorus

Recent papers, [1] and [2], dealing with aspects of the mechanism by which phosphorus is held in the soil without being immediately available to plants, show how much patient investigational work still requires to be done. This problem is of even greater practical importance now that the supply of sulphuric acid for the manufacture of superphosphate is limited, and efforts are being made to provide and evaluate alternatives.

E. G. Williams[3], in a previous article, gives a very clear exposition of the meanings of the terms in general use, and another article by the same author [4], reviewed recently, gives guidance on some problems encountered in the field.

Alan Wild[5] has published a comprehensive review of the evidence for, and the nature of, retention of phosphate by soil. This gives a list of one hundred and sixty-two references, which is extremely valuable as it includes some of the very early work, recording observations which are still not completely explained. Thus he observes that Dyer[6] analysed the continuous wheat plots at Rothamsted and found that most of the phosphate applied and not removed was still present in the top nine inches of soil, but that penetration was greater when other fertilizer salts were used in conjunction with the superphosphate, or farmyard manure had been used. Dyer[6] also found that potassium, sodium and magnesium sulphates had permitted greater penetration of the phosphate that had been applied as superphosphate, and the phosphate that was retained was more easily soluble in one per cent citric acid than on the plots not receiving these salts.

Apparently, however, contradictory results have been obtained by other workers on the effects of salts on solubility and availability of phosphorus on various types of soil, and it would seem that, in view of advances in the technique and organization of soil mapping, research workers would be well-advised to carry out their investigations on identifiable soils, typical of a named soil series, and, preferably, to include in their studies soils which present well-defined advisory problems. It would then, additionally, be possible to follow up their findings rapidly on a field scale.

The Effect of Acid Treatment

In a study of the effects of acid treatment of soils on phosphate availability and solubility, E. G. Williams[7] grew oats in a Mitscherlich pot experiment on untreated and acetic-acid-treated soil derived from basic igneous rock. He found greater P_2O_5 uptake from the acid-treated soil at all different levels of added P_2O_5. In a Neubauer experiment with oat seedlings on four soils, derived from basic igneous rock, Old Red Sandstone, slate and granite respectively, he concluded that extraction of soils with 2.5 per cent (by volume) acetic acid or 0.007 N sulphuric acid, followed by restoration of the cation content and *p*H, greatly increased the availability of the remaining phosphate.

This more than compensated for the readily soluble phosphate removed, and the treated soils gave much higher yields and P_2O_5 uptakes than the untreated soils. Williams attributes this to deactivation of fixing agents, partial hydrolysis of difficultly soluble inorganic and organic phosphates, and redistribution of phosphate in the soils.

The Fractionation of Soil Phosphorus

C. H. Williams[8], [9] and [10] has studied the fractionation of soil phosphorus in South Australian soils, using successive single extractions with 2.5 per cent acetic acid—1 per cent 8-Hydroxy-quinoline, and 0.1 N sodium hydroxide, determining the total and inorganic phosphorus, and hence the organic phosphorus by difference, in the alkali extract. He suggests that for neutral to slightly acid red-brown earth soils, either the acetic acid or inorganic alkali soluble fraction, or their sum, may be used as an index of phosphate fertility. For alkaline soils of the type examined, the inorganic alkali soluble fraction appears to be the most suitable index.

Studying calcareous Arizona soils, W. H. Fuller and W. T. McGeorge [11] found that there was a distinct relationship between the amount of water soluble phosphorus and carbonic acid soluble phosphorus, and availability of the phosphorus of the soil to barley and tomatoes, and that only a small portion of the added phosphorus was securely fixed against extraction with 1:5 water after forty-eight hours.

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C. W. R. S.
W. M. D.

The Effect of Ground Water-Level upon Productivity and Composition of Fenland Grass. A. EDEN, G. ALDERMAN and C. J. L. BAKER, and H. H. NICHOLSON and D. H. FIRTH. *J. agric. Sci.*, **41,** 191-202.

The yield and chemical composition of Italian ryegrass were investigated when the ground water-level was maintained at 15, 24 and 38 inches below ground surface. The soil was a light, calcareous Fenland peat containing 50-60 per cent organic matter and about 20 per cent calcium carbonate.

YIELD RESULTS. The total yield of dry matter for the season was 29.9, 55.9 and 54.8 cwt. per acre for the high, medium and low ground water-levels respectively; thus the maintenance of a high water-table adversely affected productivity. With the fresh grass, there was a positive correlation between the percentage dry matter and water-levels.

CHEMICAL COMPOSITION. The percentage of crude protein present in the high-level plots was lower than that of the other plots for all six cuts taken during the season. With the exception of the first cut after sowing, the medium water-level gave a lower crude protein content than the low water-level. The consistent lower protein content at the high water-level confirmed the visual impression of marked nitrogen deficiency throughout the season. The total yield of crude protein per acre was substantially different at the three water levels, being 497, 1,318 and 1,513 lb. per acre in order of increasing depth of water-level.

In respect of the crude fibre content, the differences between the three levels were small and not very consistent.

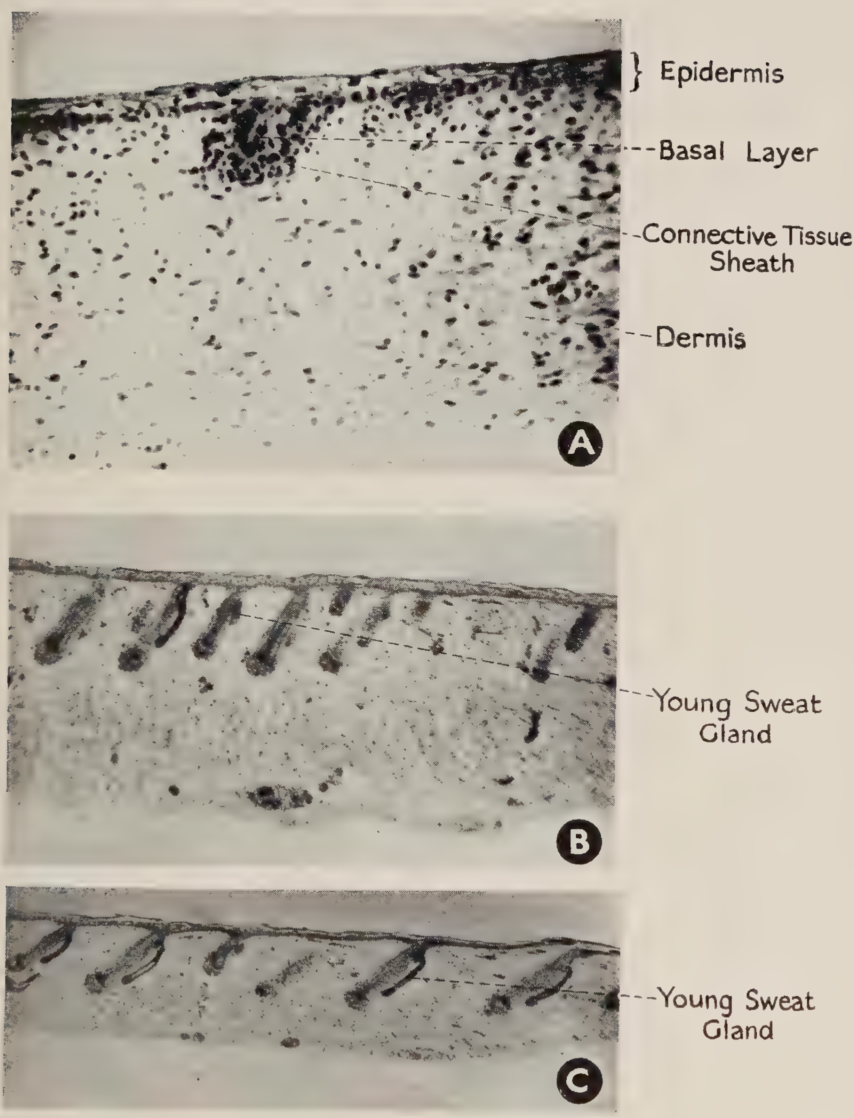
The silica-free ash figures for high-level plots were, in all cases, lower than those of the medium- and low-level plots, the differences between the latter two being negligible except in the case of the first cut when the uptake of minerals under all treatments was probably influenced by fertilizers applied at sowing. There was a rise in silica content under all treatments as the season advanced, but this was inversely proportional to the depth of the water-level.

The calcium content did not appear to be correlated with ground water-levels in this soil which contained liberal amounts of calcium carbonate. Similarly, the phosphorus content of the herbage showed little variation in relation to the water-levels, though the medium-level plots had the highest values for all six cuts. The potassium, chlorine and magnesium contents of the grass on plots of high water-levels were consistently low.

An examination of the root systems of the swards at the end of the season showed a poor root development on the high water-level plots and a deep rooting system on the low water-level plots.

The results showed that a high water-level (15 inches below ground surface) adversely influenced the productivity of grass under Fenland conditions. The maximum yields of dry matter were produced with a water-level of 24 inches below ground surface, and highest crude

WOOL (See pp. 145-53)



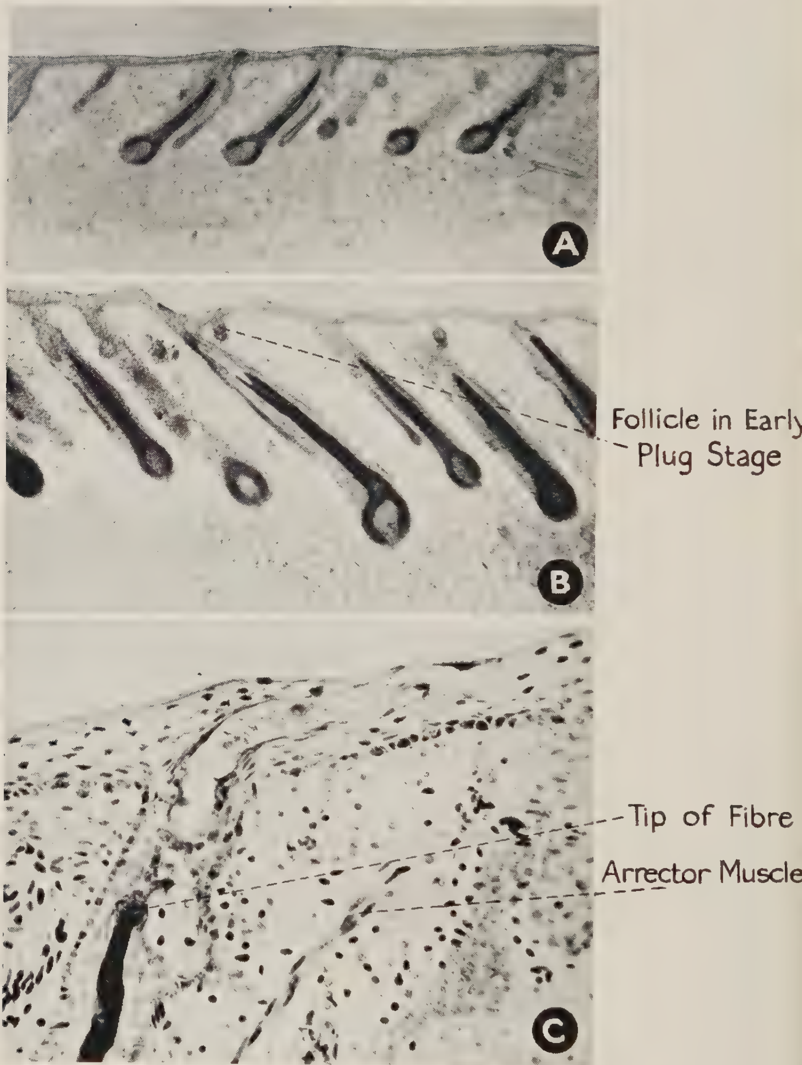
Photomicrographs from Wildman, *Proc. Zool. Soc.*, London, 1932, Pt. II

A. Vertical section through very young follicle

B. Young follicles, some showing sweat gland rudiments

C. Vertical section of skin from Southdown foetus. Stages as in B

PLATE I

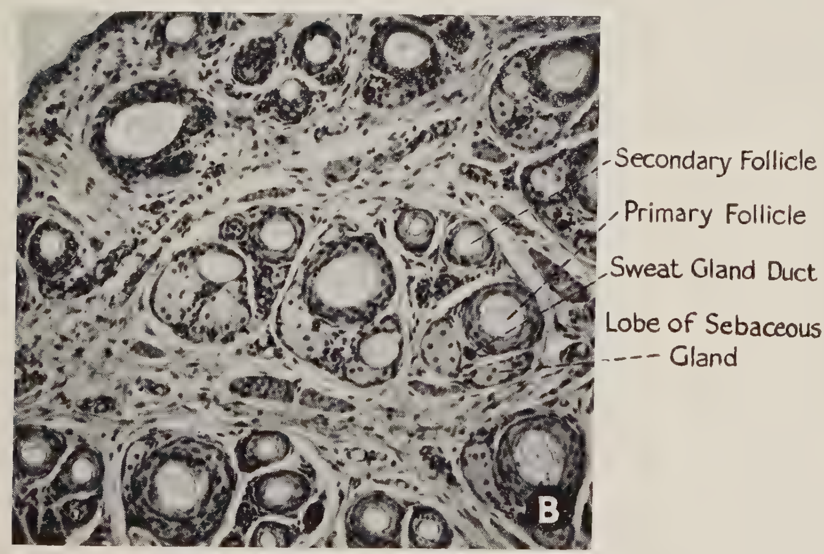


Photomicrographs from Wildman, *Proc. Zool. Soc.*, London, 1932, Pt. II

A and B. Vertical sections through follicles showing stage a little before the young fibres have pierced the skin

C. Vertical section of upper part of follicle (High Power) showing passage in epidermis excavated by seliaceous gland cells

PLATE II



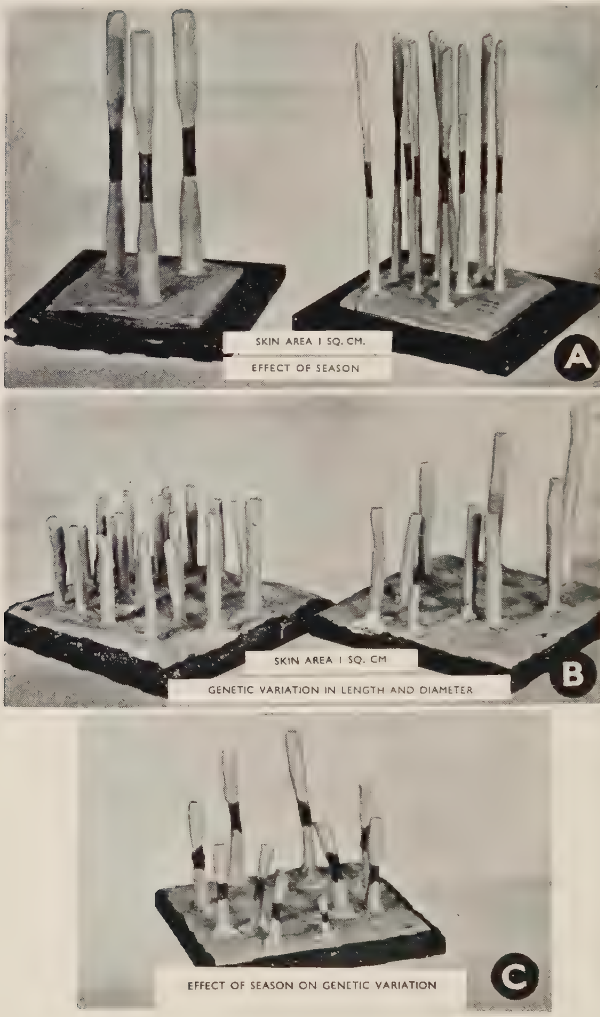
Photomicrographs : *Wool Industries Research Association*

A. The young fibre immediately after rupturing the horny layer (*stratum corneum*) of the epidermis

B. Horizontal section of skin from 16-week-old Leicester foetus, showing follicle bundle

PLATE III

WOOL (See pp. 145-53)



Photos: *Wool Industries Research Association*

A. Narrow dark bands are grown during winter period of lowest nutrition. Ideal uniformity *between* fibres

B. *Left:* Fibres uniform in length and thickness—even growth rate, and even along each fibre—no seasonal effect assumed

Right: Large genetic variation between fibres in every respect—bad. No seasonal effect assumed

C. The condition often seen: large genetic variation between fibres—bad. The effect of season occurs at different levels due to widely different growth rates of fibres

PLATE IV

protein yields with a water-level 38 inches below ground surface. As the 1949 season was one of the driest for many years, it is possible that, with normal rainfall, the maximum yields of dry matter and crude protein might be obtained with the lower water-level.

Pasture Experiments with Growing Pullets. G. F. HEUSER, L. C. NORRIS and J. H. BRUCKNER. *Bull.* 823, *Cornell Univ. agric. Exp. Sta., New York.*

The experiments reported upon were designed to investigate the benefits gained by pullets reared on pasture as compared with those having no access to grass, and included studies on the influence of access to grass on food intake, the effect of restricted feeding to birds on grass range, and the modification of rations for pullets reared on grass range.

The final weights and progress of growing pullets reared on grass were not influenced except when feed was very much restricted. When all birds had free choice of feed, there was a saving of 7-17 per cent in the food consumed by the birds on grass range as compared with those on the bare range. Thus birds having access to grass made more efficient use of food as measured by the weight of food consumed per pound of liveweight gain.

A modified ration (reduced alfalfa meal and animal protein) designed to take advantage of the nutritive value of grass, gave as good results as a more complete ration, and the saving in feed-cost per bird was greater than the saving in feed consumption. Good pastures containing a large proportion of ladino clover (white clover) increase the saving on food. Pullets were successfully reared on good pastures when the ration was limited to wheat plus minerals.

Rearing mortality, sexual maturity and later egg production were not affected, except when there was marked feed restriction.

Lamb Production on Hill Pastures. LL. I. JONES. *J. agric. Soc. Univ. Coll. Wales*, **31**, 19-23.

The hill pastures of Wales are predominantly devoted to the rearing of store lambs and draft ewes. This paper gives the results of six years' comparison of the sheep productivity of an area of unimproved hill pasture and two ploughed and reseeded pastures situated at between 1,100 and 1,300 feet above sea level. The unimproved pasture was a good bent-fescue sward representing the most productive of the natural hill swards of the region. Of the two ploughed and reseeded areas, one was sown with ordinary commercial strains of grasses and the other with Aberystwyth pedigree strains. Both the reseeded areas received 6 cwt. of basic slag and 1 cwt. of " Nitro-Chalk " per acre at the time of sowing, and a further 12 cwt. of basic slag in the fifth year.

The average ewe-carrying capacity per acre for the unimproved pasture was 1.5, but for the pastures sown with commercial and pedigree strains it was 2.4 and 2.6 respectively : the lambs reared per 100 ewes on the three pastures numbered 80, 101 and 102. Thus twice as many

lambs were reared per acre on the sown pastures as on the unimproved sward. Moreover, the lambs reared on the latter were heavier and fatter at weaning time. The full improvement in a year, as measured by weight of lambs produced per acre, was 50 lb. from the unimproved pasture, 124½ lb. from the pasture sown with commercial strains, and 140 lb. from that sown with pedigree strains.

A valuation of the lambs reared per acre showed that, during the six years of the experiment, the unimproved pasture produced lambs to the value of £12 ; the pastures sown with commercial and pedigree grasses gave lambs worth £36 and £42 respectively.

T. E. W.

MACHINERY

The Steam Sterilization of Soil. L. G. MORRIS. *Nat. Inst. Agric. Eng.* (1952).

Small quantities of soil may be sterilized in various ways, but the normal method in commercial glasshouses is to steam the soil, using a solid-fuel boiler and Hoddesdon pipes. Preliminary investigation showed wide variations in technique and fuel requirements, and a lack of fundamental knowledge. The report describes experimental work carried out to determine the minimum heat requirements of various types of soil, and the most economical steaming methods. These experiments showed that an excessive rate of steaming is wasteful. In general, it should take at least 20 minutes for the surface soil to reach 212° F. At this stage, the steam may be turned off, and sterilization will be effective if the soil is left covered for a further 5-10 minutes. Near concrete and wet patches, steam should be passed slowly for a further 5-10 minutes after the surface is cooked.

As with dairy boilers, there is no virtue in high pressure as such. In an article (*The Grower*, February 2, 1952, **37**), the same author advocates the installation of a pressure-reducing valve near the Hoddesdon pipes when large high-pressure (80 lb. per square inch) loco-type boilers are used. The area that can be sterilized in a given time is not reduced by working at low pressure, since more pipes can be used with the same boiler. A small boiler with an output of 600 lb. steam per hour can work effectively with a grid of two pipes at a pressure of 10 lb. per square inch with a 2-inch main up to 100 feet long.

For fuel economy, the soil should be as dry as possible, especially if it is of heavy texture. The heat capacity of a wet, heavy soil was found to be more than twice that of a light, dry one.

A Mechanized Market Garden with Standardised Beds. G. D. LOCKIE. *The Grower*, **36,** No. 15, 736.

Written by the estate manager of the Fernhurst Research Station, the article describes briefly the methods of working 50 acres of commercial market-garden land using a single make of tractor. A lightweight, medium-powered, four-wheeled tractor fitted with a hydraulic lift and a wide range of standard agricultural equipment was selected for all work. Two tractors are used—one full-time with its wheels set at the maximum width of 76 inches, and one part-time with its wheels usually at standard track width.

All drilling, inter-cultivation, spraying, etc., is carried out at the 76-inch track width, and all crops are drilled or planted in beds separated by pathways according to the following plan :

Crop	No. of Rows in Bed	Row Width (*inches*)	Path for Tractor Wheels (*inches*)	Typical In-Row Spacing (*inches*)	Theoretical Plant Population at Spacing Given
Lettuce, leeks, beet, spinach, onions	6	11	21	10	49,520
Cos and round lettuce, spring greens, leeks	5	14	20	9	45,850
Summer cabbage	4	17	25	17	19,400
Cauliflower, cabbage, early peas, French beans, sweet corn	3	23	30	23	10,750
Runner beans, sprouts, marrows, peas	2	35	41	35	4,716

The tractor always runs along the same wheel paths which are well marked out when the crop is drilled by running a shallow furrowing-point along the middle. Special equipment made up includes a precision cross-marker consisting of up to six individual rings of a Cambridge roll, mounted on a drilling tool-bar in the same way as the unit-type seed drills. Another useful device is a transport platform which is attached to the hydraulic lift like a buckrake.

Fruit Grading Machinery. R. J. COURSHEE. *Worcs. Agric. quart. Chron.*, February 1952, **20**, No. 1.

This article analyses the mechanisms employed in commercial grading machines, and also discusses packing, damage to fruit, and throughput of machines. A distinction is drawn between machines where quality grading is achieved by operators picking out inferior fruit from a con-

veyor, and those in which each fruit is handled individually. High throughput can be achieved by machines which employ the " subtraction " method, and this method is likely to be more satisfactory where packing can keep pace and a small proportion of blemished fruit in the pack is not a serious matter.

Sizing mechanisms may be broadly grouped into those which grade fruit by diameter, and those which grade by weight. Among the former, there is much variation. Some machines size the fruit in only one or two directions, while others rotate it and thereby achieve a more accurate sizing. In general, machines that grade by diameter tend to have a higher throughput, or to be less expensive for a given throughput, than those which grade by weight. On the other hand, a good weight grader will handle fruit of any shape, is easily adjustable, and can be used for fruit that is easily blemished.

Good graders do little damage to apples. Slight damage may occur when the fruit rolls into the receiving bin, but this is usually negligible compared with the damage incurred in picking and getting fruit to the grader.

Vegetable Washing Machines. G. BEAN. *Farm Impl. Mach. Rev.*, November 1951, **77**, No. 19.

The author discusses the importance of washing and packing, and considers the various types of machines available, water requirements, initial outlay and running costs. The principal methods adopted in washing machines are (1) spray jets, (2) " tumbling " devices, and (3) scrubbing. Individual machines employ one or a combination of these methods. In addition, a soak tank may be used either before or during the washing process.

Jet washers need a large supply of water, but are suitable for almost every kind of vegetable. Tumbler machines are mainly for carrots ; but one rotary tumbler, which incorporates a soak tank, handles crops gently and can be used for a range of vegetables. Scrubbers are used almost solely for carrots.

Machines which do not have high-pressure jets are suitable for field use where little water is available. With fixed washing machines, it is usually necessary to construct a settling tank and filter system, so that the water can be used repeatedly and mud can be kept out of the drains.

C.C.

FRUIT

Rootstock/Scion Incompatibility

The failure of certain combinations of plants to unite and grow together satisfactorily when joined by grafting has stimulated much investigation. Botanical relationship has not proved a reliable guide to the compatibility of any particular combination, and the only method of determining compatibility has been to make the combination and then to collect data on the behaviour of the tree over a period of years. The forecasting of compatibility is an urgent need at the present time when many new rootstocks and varieties are being introduced; the recent work of J. Herrero[1] at East Malling Research Station is, therefore, of particular interest.

In the past, a variety of factors have been considered as specially important. These include differences in seasonal periods of growth and vegetative vigour, biochemical differences, mechanical blockage at the union, different rates of callusing, and precipitin reactions. There is some evidence in recent years that a virus may be responsible for the failure of sweet orange grafted on sour orange ("quick decline"), certain strains of McIntosh apple and some other varieties grafted on the rootstock Spy 227, and sweet cherries infected with "buckskin disease" on Mahaleb rootstock. A further suggestion has been made that differences in size of cambial cells may cause uncongenial unions.

Herrero worked with double-grafted trees of plum and pear, using both compatible and incompatible varieties in various combinations on one rootstock, and single-grafted peach trees of one variety on two rootstocks showing different degrees of compatibility.

Plums and Pears

The records taken involved both field and laboratory studies over two years, and during this period none of the plum or pear trees showed external symptoms of incompatibility. There was no correlation between the development of the buds and compatibility. The take of grafts was high in every combination irrespective of compatibility with the exception that the few cases of graft failure occurred in those combinations with at least one incompatible variety. Shoot growth and periods of growth also failed to show a relationship.

The normal progression of cambial activity in the spring, which begins at the nodes and spreads towards the base of the tree, was proved to be unhindered by the compatibility of the union.

Thin transverse sections for microscopical examination were prepared from specimens taken at various points above and below the graft unions of a number of combinations. Differences in histological structure between the varieties grafted together were observed in many combinations, but there was no indication that the internal structures of stock and scion were more similar for the compatible combinations.

Observations were made on longitudinal surfaces exposed by cutting radially through the unions so that the relative positions of the original

cut surfaces of the grafts and the degree of union could be seen. The external appearance of the union area, after the bark had been peeled off, was also noted. Various characteristics at the line of union were recorded, the most important being discontinuity in both the wood and bark, which was the main symptom of incompatibility in plum unions ; discontinuity in the bark alone was the main symptom in pear-quince unions, discontinuous wood in these appearing only at the end of the second year's growth.

The unions showing these symptoms of incompatibility were mechanically strong except for a few of the plum combinations. There was considerable variation in the structure of the union in plums, discontinuity existing in the wood in some places, while in others well-connected wood elements of stock and scion had formed bridges. Variability observed between unions of the same combinations may in part be due to this variation in structure and the fact that only one surface through each union was exposed. Microscopic examination of the structure of the unions proved more consistent and more clearly related to the compatibilities of the combinations.

Microscopical examinations of the unions revealed certain differences between incompatible unions of pear-quince and of plums. The one-year-old unions of pears showed a striking change in the orientation of the vessels, which instead of following the normal vertical direction became horizontal. The cambium, however, was not broken at any point. In two-year-old unions, discontinuity in the wood started suddenly towards the end of the growing season as a result of the death of cells in the cambial region ; interruptions also appeared in the phloem and inner cortex of the bark. With one-year-old plum unions, discontinuity of the wood started suddenly towards the end of the first season's growth, and cambial connection between stock and scion was broken. In two-year-old unions, a new cambium was formed in early spring in some cases, re-establishing continuity and laying down continuous wood for a while until cambial continuity was again broken. In other cases, the tissues of stock and scion were separated further by widening areas of unlignified tissues. Whereas in the pears discontinuity in the bark appeared to be a sudden reaction of certain cells in the bark, and not due to a disturbance in the cambium, in plums it seemed to be the result of a slowing-up of growth at the union and disorganization of the cambium.

The distribution of starch above and below normal and incompatible unions was studied. Differences were detected in early spring by an iodine test on radial longitudinal sections, and it was found that where the starch content fell to a fairly low level in any part of the tree, the components of the tree were incompatible. That this abnormal distribution of starch was not due to mechanical blockage of the union was shown by the intermediates in some cases having a lower starch content than either top scion or rootstock, and by abnormal distribution of starch in the absence of any structural irregularity.

PEACHES

The observations on the peach combinations revealed a lower take of grafts, a cessation of scion growth and other symptoms of ill-health with the incompatible rootstock. Abnormalities at the line of union, revealed by histological examination, consisted of necrosis of the phloem of the rootstock, affecting mainly sieve tubes and companion cells, and some discontinuity of bark and wood. These abnormalities, which were associated with differences in starch distribution, were not, however, considered sufficient to account for the symptoms of ill-health in the scions, for these symptoms developed irrespective of the degree of abnormality observed ; and with plums and pears similar abnormalities in the unions were not accompanied by signs of ill-health. An interesting feature was that apparently healthy phloem was formed again when the incompatible scion was removed. Many of the features of this incompatibility are similar to those of the " quick decline " disease of citrus. It seems possible that the cause of this form of incompatibility may be different from that of the incompatibility shown by the plums and pears.

CONCLUSIONS

It is concluded that when a union is discontinuous the alteration or destruction of the cambium at the point of union is mainly responsible. The primary cause of incompatibility does not appear to be an effect of time of cambial activity, nor an effect of histological structure of the component plants. It is suggested " that some internal reaction occurs within or near the cambial cells at the union due to certain elaborated substances moving downwards towards the end of the growing season." These " may be supplied by the leaf-system of both compatible and incompatible varieties, and the way in which the cells at the union transform them is the important factor in the development of the latent antagonism giving rise to discontinuity at the line of union."

SINGLE- AND DOUBLE-GRAFTED PEARS

A further paper on incompatibility, by B. Mosse and J. Herrero[2], describes experiments with single- and double-grafted trees of Conference on Quince A and Pear C8, where the two latter appeared variously as intermediate or rootstock or as a bark ring. Certain of the resulting trees exhibited incompatibility though Conference, single-worked on either rootstock, was compatible. It was found that poor tree performance was not always associated with mechanically-defective unions but frequently with abnormal starch distribution. The degree of incompatibility appeared to be controlled by the relative positions of the rootstock and intermediate varieties, being worst whenever tissue of Quince A appeared immediately above Pear C8.

References

1. Studies of Compatible and Incompatible Graft Combinations with Special Reference to Hardy Fruit Trees. J. HERRERO, *J. Hort. Sci.*, 1951, **26,** 186-237.
2. Studies on Incompatibility between some Pear and Quince Grafts. B. MOSSE and J. HERRERO, *J. Hort. Sci.*, 1951, **26,** 238-45.

H.B.S.M.

Electrical Prewarming of Tomato House Soil. CAMERON BROWN and GOLDING. *B.E.A.I.R.A.* Tech. Rep.*, W/*T*15, 1948.

This publication describes experiments carried out to determine whether the soil temperature in tomato houses could be raised economically by electrical means to the value required for optimum planting conditions in early spring (January-March). The report is not concerned with space heating of the house, but only with soil warming prior to setting out the plants.

Much trouble had been experienced by growers, particularly in the north, through planting in soil at depressed temperatures; the only remedy was a prolonged running of the glasshouse heating plant at as high a temperature as possible in order to pass heat into the soil to a depth of several inches –a procedure which sometimes took four weeks and involved extravagant use of fuel. Grids of bare galvanized steel wires were buried in the soil at varying depths and fed from transformers at voltages of up to 35. A specific loading of 5 watts per square foot was found to be most suitable for the purpose, and the time needed to produce the required rise in temperature, i.e., to between 57° and 60° F. at 6-8 inches, proved to be about 24 hours. Taking the average figure of 0.15 kilowatt-hour per square foot as the consumption necessary to raise the soil temperature to 57-60° F., the cost (at 1d. per kilowatt-hour) for electricity alone would be 0.15d. per square foot or £27 per acre. Overhead charges on equipment include low-voltage circuit, transformer and wiring to the primary of the transformer, which, being portable and required for only a short period for each warming operation, may be used for a number of tomato houses, or for other purposes such as soil wiring in frames. The total cost of the installation, including labour, will vary from 7d. to 1s. 6d. per square foot (1948 prices) according to size and the system of working.

In general, deep laying of the 9 S.W.G. wire at about 12 inches gives a semi-permanent installation allowing normal cultivation without interference and, in general, the wire undergoes little serious deterioration when left buried in the soil for several years. Although shallow laying (6-8 inches) involves extra labour in annual coiling up and re-laying, it may be more satisfactory under some circumstances.

The design of wire installations is fully dealt with, and tables showing voltages, wire spacings and current, etc., for different lengths of grid, are provided.

It is possible to use this system for carrying on soil warming for some time after planting. The warming need not necessarily be continuous but can take place one night in four or five, so that one transformer can be used to cover a large area by " dosing " it section by section at night.

*British Electrical and Allied Industries Research Association.

Changes in the Weight of Plants as Affected by Plant Protection and Cultural Methods. E. PRIMOST. *Bodenkultur*, 1950, **4**, 77-88.

The effect of certain cultural measures on the development of tomatoes, as expressed by changes in their weight, has been studied by Werner's method, whereby the above-ground part of a plant can be weighed during growth. Tomatoes given cold water (52° F.) suffered a 16 per cent depression of growth by comparison with plants given water at 59° F. Increasing the water temperature to 77° F. did not result in any significant increase in weight. For one week following the transplanting of tomato seedlings, the weight increase was reduced by nearly 50 per cent. The application of DDT and of sulphur sprays did not hinder development of the plants at the growth stages at which they were used.

E.S.

FLOWERS

Plant Irradiation for Gladioli

Work at Beltsville, U.S.A., in 1948, showed that flowering of gladioli was influenced by photoperiod and that the effects were greater in some varieties than in others. In a recent report, Parker and Borthwick (*Flor. Rev.*, 1951, **91**, 19-20 and 50-1) have verified and extended this work. Extensive statistical experiments were carried out involving six varieties, different light treatments and different dates of starting light treatment.

Plants were given 10-hour, 12-hour and 15-hour natural daylight photoperiods, and 10-hour and 12-hour photoperiods with ½-hour and 1½-hour periods of artificial light in the middle of the dark period. Corms were planted on May 25 and treatments were begun on June 3 and June 29.

The results, which are reported in detail, showed that long photoperiods delayed flowering by 5-6 days, but increased the number of flowers in the spike and the length of the flower-stalk. A brief period of light in the middle of the dark period was as effective as a considerably longer period applied at the close of the natural day. The date of starting the photoperiodic treatment had no great effect on the results, due probably to the small variation in natural daylength at the latitude of Beltsville, but tended to show that, for the maximum effect in delaying flowering and increasing length of spike and stalk, treatment should begin immediately the plants are up.

R. H. S.

VEGETABLE CROPS

Spacing Experiments on Vegetables. I. The Effect of the Thinning Distance on Earliness in Globe Beet and Carrots in Cheshire, 1948. L. G. G. WARNE. *J. Hort Sci.*, 1951, **26**, 79-83.

Seedlings of Early Wonder carrot and Crimson Globe beet were thinned to four spacings, and the subsequent crop was harvested successionally. Close spacing reduced the mean root weight at the time when a reasonable proportion of the crop had reached usable size. Nevertheless, the largest number of roots of usable size was obtained at the closest spacings employed, i.e., one-inch for carrots and two-inch for beet.

Spacing Experiments on Vegetables. II. The Effect of the Thinning Distance on the Yields of Globe Beet, Long Beet, Carrots and Parsnips grown at Standard Inter-Row Distance in Cheshire, 1948. L. G. G. WARNE. *J. Hort. Sci.*, 1951, **26**, 84-97.

Two varieties of carrot, three of beet, and one of parsnip were grown in rows 18 inches apart, at five thinning distances. In all cases except with one variety of the beets, the total yield of roots increased as the number of plants per plot increased. Mean root weight increased with spacing distance. Grading for size revealed that the maximum yield of " large " carrots and of large globe beets were obtained at the closest spacings. Yields of large, long beet and of large parsnips were not significantly affected by spacing distance, except at very wide spacings. In general, maximum yields of large roots were obtained at much closer spacings than those usually recommended.

Close spacing decreased the incidence of bolting of both globe beet and Early Wonder carrot. Close spacing also reduced the percentage of splitting in Early Wonder carrot (though not in Altrincham).

Spacing Experiments on Vegetables. III. The Growth and Yield of Shallots in Relation to Spacing, Manuring and Size of Planting Material in Cheshire, 1948. L. G. G. WARNE. *J. Hort. Sci.*, 1951, **26**, 285-95.

In this experiment, close spacing of Dutch Yellow shallots increased susceptibility to drought and the response to manuring, accelerated ripening, and decreased the incidence of bolting and the number of daughter bulbs per plant. The use of large bulbs for planting material increased susceptibility to drought and to bolting, and increased the number of daughter bulbs per plant. When the replacement of planting material was taken into account, it was found that the maximum yields of large bulbs were obtained by planting small bulbs so as to allow not less than 48 square inches per plant. Maximum yields of small bulbs were obtained by planting small bulbs at close intervals.

Spacing Experiments on Vegetables. IV. The Yield of Globe Beet Grown at Twelve Spacings and Two Manurial Levels in Cheshire, 1948. L. G. G. WARNE. *J. Hort. Sci.*, 1951, **26**, 296-303.

Manuring with 10 cwt. per acre of a 2:2:1 NPK mixture increased the stand of plants, the total yield of roots, and the yield of large roots (over

$1\frac{7}{8}$-inch diameter). The maximum number of large roots was obtained at the closest spacing (plants spaced 2 inches apart with 9 inches between rows=240,000 plants per acre) and the maximum weight of large roots was obtained with rather wider spacings giving not less than 112,000 plants per acre.

The percentage of bolters was unaffected by any of the treatments.

The Effect of Certain Adverse Conditions on Growth and Late Development of Cauliflower and Lettuce. E. J. WINTER. *Ann. Rep. Nat. Veg. Res. Sta.*, 1951.

Cauliflowers were grown in sand culture (full nutrient solution) in five different sizes of pots. Growth rate and final size increased with increasing pot size. Curding and flowering were delayed in the small sizes of pots.

In the field, hearting and bolting of lettuce were delayed by close spacing, and by transplanting in late June.

The Effect of Fertilizers on the Plaster of Paris Electrical Resistance Method for Measuring Soil Moisture in the Field. G. J. BOUYOUCOS. *Agron. J.*, 1951, **43,** 508-11.

The commercial model of the Bouyoucos soil moisture meter (see *N.A.A.S. Quarterly Review No.* 14, 68) is calibrated directly in percentage of available water. No means are provided for adjusting the calibration for use in soils of different types, or in soils to which different quantities of fertilizers have been added.

Experiments described in this article show that the moisture meter is reasonably accurate from wilting point to field capacity in most soils with medium to low salt content, and in soils to which not more than 1,000 lb. per acre of inorganic fertilizers have been applied. In soils which have received 1,000-2,000 lb. fertilizers, the meter is accurate enough for practical irrigation purposes between wilting percentage and 85-95 per cent available water. The errors are most serious in sands and silts.

The version of the soil moisture bridge used in scientific work is not calibrated directly in percentage moisture, and allowances can therefore be made for differences in soil type and manurial treatment.

E.J.W.

PLANT BREEDING

French Lucernes

In view of the importance of France as a source of lucerne seed for use in England, special interest attaches to a survey, by Mayer, Vincent and Ecochard [1], of French populations of lucerne. As with red clover and sainfoin in England and Wales, so with lucerne in France the foundation of the varietal structure is provided by local strains, maintained either by farmers who grow their own seed or by certain seed firms who reproduce particular stocks by means of contract crops.

By confining their attention to stocks of some authenticity, the authors have been able to recognize and define three main types of French lucerne : *Provence*, *West French* and *Flanders*,* the main distinguishing features of which are summarized below :

Distinguishing Features of Three Main Types of French Lucerne

	Provence	*West French*	*Flanders*
1. Percentage variegated	5	22	12
2. Pods—no. of turns	2.4-3.2	1.4-2.4	2-2.3
3. Percentage kidney-shaped seeds	39-60	11-39	39-60
4. Percentage tap roots	56	56	33
5. Winter rosettes...	Few	Medium	Medium
6. Earliness of flowering	Semi-early	Semi-early	Early
7. Stem thickness...	Medium	Medium	Thick
8. Leafiness	Leafy	Leafy	Medium
9. Frost resistance	Susceptible	Fairly susceptible	Fairly resistant

Row 1 gives the proportion of plants with variegated flowers, i.e., those showing some visible sign of yellow pigment as well as purple anthocyanin. The figures in row 2 are reached by counting the number of *complete* turns in the spiral (ignoring a fraction of a turn) and averaging for three pods from a stem, each pod being the most twisted from the top, middle and bottom inflorescence ; the figures given show the range found in respect of averages of fifty stems each. The figures in row 3 were obtained by classifying a bulk of seed into two classes—" reniform " and " round " (similar in shape to red clover seed). Row 4 shows the percentage of plants with distinct, non-fangy, tap roots. Row 5 shows the proportion of plants with no shoot elongation in the winter. The remaining rows are self-explanatory.

The authors distinguish sub-groups of the West French group under the names *Poitou* and *Marais* ; the latter has only 33 per cent plants with tap-roots. A sub-group of the Flanders lucernes, called *Ormelong*, has 56 per cent tap-roots.

The area in which typical Provence populations are found centres roughly on Avignon ; the *West French* group centres on Poitiers, the *Marais* sub-group being limited to near the Atlantic coast ; the Flanders group is, of course, found in the French part of Flanders (Depts. Pas de Calais and Nord) but it also has a disjunct area in Beauce, where the *Ormelong* sub-group predominates.

The results are also given of a trial at Versailles, in which *Provence*,

* The French name for this type, *Flamande*, is usually translated as " Flemish," but " Flanders " conveys more exactly the geographical meaning implied in this case.

Poitou, *Flanders* and *Ormelong* were compared under different treatments and at different row-widths. The *Flanders* types gave the greatest yield but appeared less persistent than *Poitou*, which outyielded *Provence*.

Synthetic Brassica Napus

The Japanese workers were the first to discover that the brassica species with high chromosome numbers could be " synthesized " by crossing species with low numbers. Rudorf [2] has been investigating the application of this method to improving the winter-sown oil seed type of *B. Napus* grown in Germany. The starting point is the cross between the species with $2n=20$ (*B. campestris*, *B. Rapa*), and that with $2n=18$ (*B. oleracea*). The F_1 hybrid has $2n=19$ and is effectively a haploid *B. Napus*. From the F_1, diploid forms with $2n=38$ were obtained in a variety of ways : (a) by self-pollinating the F_1 plants, a high proportion of $2n=38$ plants were produced by the functioning of unreduced pollen grains and embryo-sacs ; (b) on pollinating the F_1 with *B. Napus*, a very high proportion of $2n=38$ plants was obtained ; (*c*) backcrossing once or twice to *B. Rapa*, with selection for *Napus*-like characters, produced some plants with $2n=38$.

Continuing selection for *Napus*-like features for two generations, with checks on the chromosome number, was practised. Some of the lines have exceeded the standard (Lembke's winter oil-seed rape) in yield and some are better in respect of winter-hardiness and weight per thousand seeds.

Two other methods by which Rudorf obtained synthetic *B. Napus* are worth mentioning, for they illustrate the fact that text-book rules are frequently broken in work on polyploidy. In one method, Rudorf treated the two parent species with colchicine to double their chromosome numbers, and then crossed the supposed tetraploids. This should have produced F_1 plants with $2n=38$, but in fact the only two plants obtained from the cross had $2n=76$. On crossing these with *B. Napus*, he should have obtained only triploids ($2n=57$) but, in fact, he obtained plants with about 38 chromosomes. The other method consisted of pollinating diploid *B. campestris* ($2n=10$) with tetraploid *B. oleracea* ($2n=36$) and pollinating the hybrid by *B. Napus*. This produced forms with $2n=38$ and of normal fertility—a result which is not inexplicable but a little unexpected.

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J.L.F.

DAIRY HUSBANDRY

Factors Affecting Lactation

From time to time, studies have been made of some of the factors affecting lactation, using data collected from milk-recorded herds. Two useful contributions of this type have appeared recently, the first by Edwards (*J. agric. Sci.*, 1950, **40,** 100) and the second by Mahadevan (*ibid.*, 1951, **41,** 80-97). Edwards used lactation data concerning pedigree Jersey cattle submitted for the Register of Merit, and also that collected from a pedigree herd of Jerseys over a period of thirty-five years. This study is mainly concerned with the relationship between the secretion of milk and butter fat. It is of particular interest so far as a comparison between the morning and evening milkings is concerned. With these particular data, the mean lactation curve for evening milk production, from the forty-fifth day after calving onwards, is almost a straight line, indicating a decline in secretory activity at a regular rate. The mean lactation curve for morning milk production shows a similar rate of decline after the hundred and eightieth day from calving, but prior to this, the rate of fall is less rapid, and Edwards suggests that this is due to a reduction in the rate of secretion before the morning milking, in early lactation, due to pressure within the udder.

Data on fat production indicate that the inhibitory effect of pressure is even greater on fat production than on milk production. Cows vary in udder capacity, and consequently in the inhibitory effect of udder pressure, and it is suggested that the ratio of the rate of secretion during the night interval (morning yield divided by number of hours between afternoon and morning milking) to the rate of secretion during the day interval (evening yield divided by number of hours between morning and afternoon milking) may give a guide as to the response in total production likely to result from a change from twice to thrice a day milking. These data also provide further evidence that low fat concentration in morning milk is not due only to differential rates of inhibition of the secretion of milk and fat, due to udder pressure, but is partly due to factors associated with "night" itself. A specific effect of the season of the year on fat concentration also becomes evident when the effect of milk volume is eliminated, and Edwards concluded that fat secretion must be fairly sensitive to the cow's environment.

Mahadevan made use of data from twelve pedigree Ayrshire herds over a period of ten years, and he has studied the effect of environment and heredity on milk yield, persistency of lactation and butterfat percentage. In the work on yield and persistency, the production during the first hundred and eighty days of the lactation period was used in order to eliminate effect of the variable calving intervals. Useful information on the effect of the month of calving, age, and length of the preceding calving interval is included. On average, the winter calvers outyielded summer calvers by about 10 per cent. Mahadevan found that the correction of early lactations to mature lactations was best done by percentage additions rather than by standard additions

unrelated to level of production. On economic grounds, a calving interval of about one year appeared to be preferable except for the first lactation, where four hundred days was justified. By a study of correlations between yields in different lactations of the same cows, and between lactations of dams and daughters in the same herd, conclusions are drawn as to the scope for improvement in yield, by better feeding and management or by selective breeding of females. Owing to the low heritability of milk yield and persistency of lactation, and to the long period between generations, the rate of improvement by mass selection was inevitably very slow. On the other hand, the heritability of butterfat percentage was of a substantially higher order, and improvement by mass selection held promise of success in a shorter period.

The Teat Orifice

Dodd and Neave (*J. Dairy Res.*, 1951, **18**, 240-5) have provided conclusive evidence that the incidence of subclinical and clinical mastitis is much greater in fast-milking heifers than in slow milkers. Since Baxter, Clarke, Dodd and Foot (*ibid.*, 1950, **17**, 117) have previously shown that the rate of milking is greatly influenced by the size of the teat orifice, there remains an important question as to its optimum dimension, especially since the size appears to be fairly highly heritable. On grounds of labour economy, there seems to be a very strong case for the elimination of the animal with the orifice which is so small that machine milking takes more than seven or eight minutes, but beyond this, it would be difficult at present to advise on teat orifice size.

Herd Fertility

While the treatment of individual infertile cows is mainly a veterinary matter, evidence continues to accumulate indicating that feeding and management can, on a long term basis, have a marked effect on herd fertility. Hignett (*Vet. Record*, 1950, **62**, 651) suggested that a proportion of the infertility in dairy herds is nutritional in origin and that one of the major factors may be a deficiency of phosphorus in the dairy cow's present diet. Recently, Hignett and Hignett have provided some evidence on this point (*ibid.*, 1951, **63**, 603). In the group of herds studied, a small proportion appeared to receive in their diet a level of phosphorus below that normally recommended by the Ministry (*Bulletin No. 48*), and of these some appeared to show a lower conception to first service. The danger of a phosphorus shortage in dairy cow diets is, of course, somewhat greater owing to the use of greater quantities of lucerne, clover, kale, etc., which usually provide an abundance of calcium.

There is, however, no reliable evidence of infertility due to nutritional causes on a widespread basis in Britain, and apart from that due to the specific "fertility" diseases, the possibility of conception followed by early abortion or early embryonic reabsorption must not be ruled out. That this may occur on a substantial scale has been clearly demonstrated, for example, by Tenabe and Casida (*J. Dairy Sci.*, 1949, **32**, 237). On a herd basis, it is possible that some evidence of the existence or absence of this latter type of infertility may be obtained by studying

the period between service, the next oestrus and subsequent oestrus. In the case of non-conception, it is reasonable to expect a large proportion of cows to come in season near the 21st, 42nd and 63rd day after service. Asdell, d'Alba and Roberts (*Cornell Veterinarian*, 1949, **39,** 389) found that, of the particular group of cows which they studied, 90 per cent returning to the bull came on heat within a range of seven days, about the 21st day.

A recent study by Olds and Seath (*J. Dairy Sci.*, 1951, **34,** 626) gives further data on the length of the oestrus cycle, but in this case only 66.7 per cent of the cycles fell between seventeen and twenty-six days after previous oestrus when *no* service had taken place. It is clear, therefore, that considerable care is needed in attempting to diagnose the type of infertility involved in a herd by a study of the breeding records.

A. S. F.

POULTRY HUSBANDRY

Egg Quality

Investigations into egg quality standards and methods directed towards the elimination of egg faults, continue to be popular themes for research papers. One of the most troublesome of faults in eggs is the blood spot, and in an article, "Blood-Spotting in Eggs", L. W. Taylor, I. M. Lerner and D. C. Lowrey in *California Agriculture*, 1951, **5,** 3, discuss means of reducing the incidence of eggs with blood-spots in a flock. Although the fault is highly heritable, the authors point out that there are practical difficulties in the way of proceeding on the customary basis of individual selection. In the first instance, it may not be feasible for a farmer to trap-nest every bird throughout the year and to candle every egg. Secondly, as the incidence of the fault is reduced, statistical considerations limit the value of individual selection. In practice, therefore, combined family and individual selection should be followed to eradicate the production of eggs with blood-spots.

A fault which is more commonly encountered in stored eggs is the amber white. The amber-coloured tinge of varying intensity which appears in the white of some eggs during storage in a thawed state, after they have been frozen at temperatures above -6°C., is described by H. P. Hale in " Production of Amber Whites in Shell Eggs by Freezing and Thawing " (*J. Sci. Food Agric.*, 1950, **1,** 46-8). The discoloration

of the white is caused by leakage from the yolk consequent upon the increased permeability of the vitelline membrane. The author doubts whether the increased permeability of the vitelline membrane is due to ice spicules puncturing the membrane, and draws attention to a discoloration of a similar nature found in the eggs produced by certain birds when malvaceous herbage is ingested. The discoloration only appears after a lapse of some time. In both instances the mechanism whereby the vitelline membrane increases in permeability remains to be determined.

Another aspect of egg quality is dealt with in a paper on " Variations in the Pigment and Vitamin A Contents of Egg Yolk," by F. H. Grimbleby and D. J. G. Black, in the *Brit. J. Nutr.*, 1950, **4**, 323-31. The data presented by these authors indicate that vitamin A and carotenoid pigment, stored before laying, are transferred at a high level to the first few eggs laid. As the laying period progresses, the rates of concentration in the egg decline rapidly. The importance of this variation to the breeder, in connection with hatching rates, is stressed.

On an allied subject, " Egg Shell Colour and Hatchability," by M. M. Rosenberg and T. Tanaka (*Poult. Sci.*, 1951, **30**, 713-6), evidence is presented to support the authors' views that there is no relationship between shell colour and hatchability.

Management

The need for increased winter production has led to greater interest in the lighting of flocks, and two papers on the effect of light are therefore of topical interest. " The Effect of Controlled Light and Temperature for Laying Hens," by C. D. Mueller, T. B. Avery, H. D. Smith and R. E. Clegg (*Poult. Sci.*, 1951, **30**, 679-86), gives an account of the differences observed in chickens reared and carried over a two-year period under constant temperature (60°F.) and constant levels of light (twelve hours daily), and birds reared and carried under atmospheric conditions (apart from the hover-temperature during early growth). The data presented by the authors indicate that, with birds under atmospheric conditions, mortality was higher, and egg production was lower. The chicks exposed to atmospheric conditions (away from the hover) grew more rapidly up to eight weeks, but this difference was lost by twelve weeks of age. High environmental temperature depressed egg size ; albumen quality was better under controlled lighting and temperature. On a somewhat similar topic, " The Influence of Intermittent Periods of Light and Dark on the Rate of Growth of Chicks," by R. E. Clegg and P. E. Sanford (*ibid.*, 760-2), the co-authors found that chicks having alternate six-hour periods of light and dark were substantially heavier at six weeks of age than chicks having twelve-hour periods. Further gains in weight were observed with chicks when the periods of light and dark were changed to two hours. The weight differences were sustained with little change up to about roaster-stage.

Breeding

In " Poultry Breeding " (*California Agriculture*, 1951, **5**, 15) I. M. Lerner discusses the difficulty experienced by most breeders in maintaining improvement for a given trait once a certain standard is reached. The author illustrates his theme by giving an account of the progress that can be achieved in breeding for increased shank length. At a certain stage a check to further improvement is encountered. This check is attributed by Lerner largely to the decline in the reproductive capability of the bird—a decrease in fertility, egg numbers, hatchability and chick viability in the experimental group. Lerner considers that a bird (or animal) is a well-balanced organism and that, if a single trait is selected towards extreme development, that development of a specific character may interfere with the balance of the organism. The author considers that, possibly, constant endeavour in maintaining selection for the desired characteristic may ultimately result in the bird adjusting itself to a new state of balance, when further improvement for the desired characteristic and recovery of productive capacity is possible. If this theory be correct, the author considers that patient endeavour by the breeder may allow him to break through the " ceiling " for a given trait. It will be apparent that with a complex characteristic such as egg production, considerable patience to achieve further gains may be necessary once a high " plateau " of production is reached.

R.C.

MYCOLOGY

Red Core Disease of Strawberries

Following field observations that the development of Red Core disease of strawberries, due to *Phytopthora fragariae* Hickman, varied with soil moisture and *p*H, Hickman and English [1] studied the effects of these factors in controlled pot experiments. They found that, in a free-draining soil, the greatest amount of root infection occurred when soil moisture was high, due either to frequent watering from above or to waterlogging caused by standing the pots in saucers of water. These high moisture conditions favoured the liberation of zoospores which may be carried by movement of soil water to roots some distance from the point of initial infection. When soils of varying texture were studied, the greatest amount of infection occurred in the lighter soils, watering being carried out every four days or more often. With all soil textures, the more frequent the watering the greater was the degree of infection. When the *p*H of two soils was adjusted to four different levels, there was less disease in the more alkaline pots. Similar experiments carried out

with soils, occurring naturally and of varying *p*H, resulted in heavy infection in four out of twelve alkaline soils, indicating that there is no simple relationship between *p*H and degree of infection. The authors discuss the experimental results obtained in relation to the conditions under which the disease occurs in the field.

Reid [2], in an account of his strawberry breeding work at Auchincruive, describes the development of his varieties resistant to Red Core. Up to 1949, some 40,000 seedlings of 550 different families were tested. The seedlings were grown in boxes of soil contaminated with Red Core, and those not infected were planted in contaminated plots in the open for two years. Any which did not develop symptoms of Red Core were fruited, and those resistant plants with good fruiting qualities were further tested on commercial holdings where the disease was present. By autumn 1941, five selections, Auchincruive 1, 2, 4, 5 and 6, were released to growers. Of these, 1, 5 and 6 are still grown successfully in the Clydeside area where the disease is present, although small patches of infection have occasionally appeared. In 1939, as a result of a cross between a third generation seedling of the Scottish variety No. 52 (possibly Frith) and the American resistant variety Aberdeen, a seedling was obtained with a very high degree of resistance to Red Core. This was released in 1947 under the name Auchincruive Climax. Up to 1948, it appeared immune to the disease, but since then occasional cases of infection have occurred under conditions very favourable to infection. However, in most plantings resistance has been well maintained, especially in comparison to other varieties grown alongside.

The reasons for the breakdown in resistance to Red Core of some varieties have been studied both in America and Britain. In America, Scott, Jeffers, Darrow and Ink [3] found that some American resistant varieties broke down when grown in certain localities, but seedlings of Scottish parentage did not. Plants of Scottish and American strains were then grown in a greenhouse in soils from four sites where the disease was present. In one soil, the infection obtained was not uniform ; in two others, the American varieties proved susceptible and the Scottish seedlings resistant ; in the fourth soil, the latter result was reversed. The authors, therefore, conclude that at least two strains of the fungus must exist.

More recently, Hickman and English [4] have tested the resistance of the varieties Perle de Prague, Auchincruive Climax, and Huxley in standardized pot experiments using pure cultures of *P. fragariae* from eight different sources. From the results of their experiments, they were able to separate the isolates into three physiologic races. Race 1 is highly pathogenic to Huxley, very slightly pathogenic to Perle de Prague and non-pathogenic to Climax. Race 2 is highly pathogenic to Huxley and Perle de Prague and non-pathogenic to Climax. Race 3 is highly pathogenic to Huxley and Climax, but only very slightly pathogenic to Perle de Prague.

Stoddard [5], in America, has obtained a control of Red Core under greenhouse conditions by watering plants, which are growing in sand,

five times with 1.5 per cent Dithane D.14 prior to planting in contaminated soil. He also found that watering infected areas in the field with 1.5 per cent D.14 prevented spread of the disease to neighbouring plants, for two seasons. Later [6], he claimed in a field trial in Connecticut that watering with 1.5 per cent Dithane D.14, at a rate of 2,000 gallons per acre and at the start of flowering in May, controlled the disease.

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H.E.C.

PROVINCIAL NOTE

RABBITS AND THE FARMER

D. W. EMPSON and W. E. H. HODSON

N.A.A.S., South-Eastern Province

The rabbit is a pest. This is agreed by all field naturalists, all agricultural scientists and by many farmers. But in spite of this wide agreement, there is, among country people, an understandable reluctance to treat rabbits as vermin. The country in its present state cannot, however, afford to neglect the rabbit problem. It becomes, therefore, one of the duties of the N.A.A.S. to lay before the agricultural community the facts of the case and to set up experiments to measure and demonstrate exactly how much damage to agriculture is attributable to rabbits and to rabbits alone.

A series of simple experiments, consisting of pairs of equal-sized plots of winter wheat, one surrounded by rabbit-proof wire netting and the other left open, has been set up on sites selected at random all over England and Wales. Not the least valuable feature of these experiments

is the keen interest shown in them, and the discussion, often heated, that they have aroused. Although the rabbit is probably our most intensively studied mammal, there can be few creatures about whose economic status more widely differing views are held by experienced countrymen.

Recognition of Rabbit Grazing

Well over half our fields of winter wheat, when examined in February, show noticeable rabbit grazing. And although this is no new development, it comes as a surprise to many farmers to learn the real cause of such a crop " going back". The recognition of damage is, therefore, of first importance.

The rabbit bites off the leaf or leaves of a young cereal plant with a clean cut, at least a quarter of an inch above ground level. In this it differs from pests such as wireworms, leatherjackets and slugs, which either cut into the stem at or below ground level or, if the leaves are attacked, rasp away the tissues so that a ragged and untidy end is left.

Having observed that the leaves have been bitten off cleanly, final identification of rabbit grazing is a matter of elimination. All the creatures listed below may cause somewhat similar damage and must be considered in turn.

Birds. Flocks of small birds, probably linnets, and sometimes skylarks, will injure winter cereal crops, but the damage may be distinguished from that caused by rabbits since the cut end of the leaf is either notched or cut diagonally, and not straight across the leaf. Many leaves, not completely severed, show obvious V-shaped beak marks and, as a rule, pecked-off tips of leaves may be found lying on the surface of the soil. Finally, if the field is visited immediately after the attack, numerous small white bird droppings may be found.

Deer. During the last few years, grazing by deer in wooded country has not been uncommon. Identification is normally possible from the hoof-marks or slots and from the droppings. This also applies to grazing by horses, cattle or sheep.

Hares. These are creatures of open, undulating land and their grazing is generally confined to places where they have a good view of the surrounding countryside. Rabbits, however, will also feed in such areas, and separation is not always easy. The best guide is an examination of the droppings. Those of rabbits are rounded at the ends whereas those of hares are larger and more pointed. It is necessary to examine a number of individual droppings before this rule can be applied, though, since the distinction is not always clear.

Field Mice. Grazing by field mice is very similar to that caused by rabbits, and identification is complicated by the tendency of rabbits and mice to abound in the same sheltered areas. Mouse grazing may be recognized by the very sharp line of demarcation between the grazed and ungrazed areas. The animals start at the edge of the field and graze along a single line—the " feeding front"—which advances across the field at the rate of a few yards a night. This advance of damage across the field, or towards the centre from each side, is often seen with rabbit grazing, but the feeding front is never so sharply defined.

When mice are grazing winter corn, they store large numbers of leaves in piles around the edge of the field. This explains why such small animals can do so much damage. The piles of green leaf tips may be under logs, beneath tufts of grass or under tree roots. Where it is desired to catch a few mice for identification, traps (baited as for house mice) should be placed at the feeding front; they are likely to be ineffective elsewhere.

Assuming that the damage does not appear to be due to any of the causes listed above, it can be taken that rabbits are to blame.

It will be observed that rabbit droppings, "scrapes" and runs have not been listed as positive means of identification. All may be found in fields which are not being severely grazed, or have been damaged by other agencies: but, on some soils, and after exceptionally heavy rain, practically all traces of rabbits (except the damage) may be removed.

Habits of the Species

There is insufficient space here to do more than outline some of the main features of rabbit behaviour. They live socially in warrens, dislike damp places, feed mainly at night, and often travel long distances by using clearly-marked runs. Apart from these characteristics, rabbits seem, at any rate to the human observer, to be creatures of whim rather than habit. They have been known to climb trees, turn upon and drive away stoats, and cross fairly wide streams, and it is these exceptions to the normal rules of behaviour that have made the rabbit the subject of innumerable debates and anecdotes. In spite of this, when rabbits are considered as a whole rather than as individuals, their habits are fairly constant and well known among countrymen.

Rabbits will apparently travel well over a mile in search of food, but this distance is only likely to become usual in time of scarcity. Often, however, a rabbit-run may be traced through undamaged and apparently suitable crops to a single field that is grazed bare. One can only suppose that the undamaged crops are, for some unexplained reason, comparatively unpalatable. Sometimes rabbits will eat off a field systematically, working towards the centre, but often they graze indiscriminately over the whole field so that the crop is uneven. At other times they will confine their attention to small patches in the crop (usually the drier areas) and will desert the field rather than extend these patches.

Their ability to surmount obstacles when food is scarce is phenomenal; but where alternative food is available, low wire netting suffices to deter them. One interesting characteristic is that a rabbit does not like to get its nose dirty, and so will not touch the soil when feeding. Because of this, many crops sown in a rough tilth have escaped what would otherwise have been almost certain destruction since the rabbits could not reach and bite off enough of the leaf to check the young plants at all seriously.

Rabbits start breeding at about six months old, and by the end of a year a pair could have about a hundred descendants. Although they have many natural enemies, they can more than hold their own under normal agricultural conditions. There can be no doubt that shooting is quite

inadequate to reduce their numbers to anything approaching a safe level, and while it is admitted that every little helps, the main attack must be by gassing.

The loss of rabbit meat by gassing is considerably less than the gain in agricultural produce that results, even if protein alone is considered.

Crops Attacked

Practically all agricultural crops may be attacked, and young trees are often damaged, but grass is the rabbit's staple food. Vegetables of all sorts are taken, but probably the most serious damage is done to winter corn. Of the three main cereals, wheat is preferred followed by barley and then oats. Where wheat and oats are growing side by side, the wheat is taken first, but if no other wheat or barley is available they will then graze the oats.

It is sometimes stated that if the wheat grows away sufficiently well after sowing, it soon becomes unpalatable and will not be attacked. This is not borne out by an experiment in which wheat was protected from sowing until the middle of February, by which time the plants were between 4 and 6 inches high. Two days after the wire was removed the plot was visited and the crop was eaten down almost to the ground.

Damage to corn is most serious when the winter is long and plant growth is at a standstill for a month or more. As soon as the grass starts growing, the attacks on cereals lessen and cases of damage to spring corn are comparatively few. Spring-sown corn, however, is less able to recover from severe grazing than winter corn. Thus the slighter degree of grazing on spring corn may result in damage as bad, or even more serious than that from much heavier grazing on winter-sown cereals. A survey of damage to spring wheat in Kent in 1950, carried out by the Infestation Control Division of the Ministry of Agriculture and Fisheries, indicated that the loss in Kent averaged rather more than 10 per cent, or about 3 cwt. per acre of all the spring wheat sown.

Recovery after Grazing

Too little is known about this subject, but work is proceeding to clarify the situation. It is apparent that some fields do not give an economic crop after severe grazing whereas others yield reasonably well. Two main factors seem to be involved : first, the amount of growth that takes place before the crop is eaten off for the first time ; secondly, the length of time that the crop is subject to severe grazing during growing weather. Nevertheless, it is extremely difficult to say when a crop should be ploughed in and when it should be left to recover. It is known that a field which appears quite brown in March can give an astonishingly high yield, but it is also known that this yield is well below the possible output of the field. In many cases, a farmer has consistently suffered from rabbit damage to crops, and his ideas of what constitutes a satisfactory return from the field are reduced accordingly. The only advice that can be given at this stage is that if the plants, when examined in March, have a root system almost as good as those in ungrazed fields, the crop is probably worth saving. Where root growth is slight, the risk should not be taken.

Loss of Grain by Rabbit Grazing

The loss of grain through rabbit damage is a matter of national concern, and steps have been taken to tackle the problem on a national basis.

During the season 1950-51, detailed surveys were made in four areas—in the South-Eastern, Eastern, and West Midlands Provinces and in the South-Eastern Sub-Province. A survey was made on winter wheat in 1951, and on 100 fields selected at random in the South-Eastern Province the farmer was asked to give his estimate of the loss of grain attributable to rabbit grazing. The average estimate was 5 per cent or about 1 cwt. per acre. Damage was, however, more or less confined to about 15 per cent of the fields examined ; in these fields, the reduction varied from 25 per cent to complete destruction of the crop. Similar results were obtained in the Eastern and other provinces, and it appears, therefore, that the amount of wheat lost to the country during the year must have been of the order of 75,000 tons. This year, a more careful survey is being carried out, the losses being measured instead of estimated.

It should be remembered that damage to winter wheat is only a part of the score against the rabbit. The loss of grazing alone must be enormous, although it has not actually been measured ; and the loss of other crops is considerable.

It is stated by F. Howard Lancum (Wild Mammals and the Land, *Ministry of Agriculture Bulletin No. 150*) that "A rabbit will make a meal for two or three people : that same rabbit in a year will destroy more food than three people could eat in a week." The rabbit is classed, after the rat, as agriculture's enemy No. 2, and its control continues to be of vital importance to the industry and to the country.

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